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ABSTRACT

This report reviews and summarizes the findings of a research and development project investigating effective pedagogy using Information and Communications Technology (ICT) in literacy and numeracy in primary schools in Great Britain. It also provides information about the main stages of the research process and the model of teaching and learning underpinning the team's approach to supporting and investigating teachers' development, and it provides illustrations of effective practice rich enough to encompass the complexity of the choices teachers have made in deciding when, when not and how to use ICT to strengthen their teaching in literacy and numeracy. Included in the report are a number of examples illustrating effective use of ICT by teachers. After a summary and an outline description of the project, the report presents 12 illustrations showing how teachers in the project used ICT to support their teaching of literacy and numeracy; these illustrations are the main outcomes from the development work and its analysis. (Contains 12 tables and figures of data. Appendixes contain survey results, existing research and publications about ICT, a brief review of research on effective pedagogy, some relationships between teachers' thinking and observed behavior, the range of schools in the development phase, gains in pupils' attainment during the development work, and a 15-item list of related Web sites.) (RS)

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Ways forward with ICT:

Effective Pedagogy using Information and Communications Technology for Literacy and Numeracy in Primary Schools

by a team from

Newcastle University

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CS 510 665

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and CEM Centre, Durham University

Peter Tymms, Brian Henderson and Jane Stout.

September 1999

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Thanks also go to the advisers and supporters of the project both within the academic community, particularly the team at the CEM (Curriculum Evaluation and Management Centre) at Durham University and colleagues at Newcastle, as well as colleagues in local schools, the teachers, head teachers and LEA staff. The knowledge and advice offered by them helped to keep the project focused and on track. We are also grateful to the staff of Lancashire's Educational Psychology Service and Derek Webster, its Principal, as well as to Wendy Woodcock for all of their help with the observations undertaken during the project.

Finally, whilst the views and interpretations expressed here are those of the project team based at Newcastle University, we would like to extend our thanks to the Teacher Training Agency and the officers and steering committee members for their advice and guidance both on the completion of project and the production of this report.

Introduction

This report:

- **reviews and summarises the findings of a research and development project investigating effective pedagogy using Information and Communications Technology (ICT) in literacy and numeracy in primary schools;**
- **provides information about the main stages of the research process and the model of teaching and learning underpinning the team's approach to supporting and investigating teachers' development;**
- **provides illustrations of effective practice rich enough to encompass the complexity of the choices teachers have made in deciding when, when not and how to use ICT to strengthen their teaching in literacy and numeracy.**

Aims

The main aim of this report is to provide an overview of the work of the project team and the work of the teachers they supported. The project investigated the contribution that ICT can make to effective teaching and learning in literacy and numeracy in primary schools. This report forms one of the major outcomes from a two year research and development project funded by the Teacher Training Agency (TTA).

Content and structure of the report

Included in the report are a number of examples illustrating effective use of ICT by teachers. These illustrations of developing practice are intended both to exemplify effective teaching in literacy and numeracy with ICT as well as to describe the development work undertaken as part of this research project. The illustrations are set within an overall school context and are written for teachers. They provide a range of examples of teaching in classrooms that illustrate the functions of ICT in the TTA's Initial Teacher Training National Curriculum (DfEE, 1998) which forms the benchmark for the needs identification and the Expected Outcomes for New

Opportunities Fund (NOF) training for existing teachers which began in 1999.

A substantial amount of information has been collected during the course of the project and only part of this can be reported here. The intention of the data collection was to provide a robust evidence base on which to set the reporting of the development work, rather than to draw incontrovertible conclusions about what is, or is not effective. The purpose of the initiative was to provide information and support for teachers using ICT to help raise levels of pupils' achievement in primary schools, and to inform the work of those who support them.

The structure of the report is as follows:

- a summary which signposts key messages and further sections of the report;
- an outline description of the project as a whole and the sources of data for the research and development work;
- twelve illustrations showing how teachers in the project used ICT to support their teaching of literacy and numeracy; these illustrations are the main outcomes from the development work and its analysis.

The remaining sections of the report provide the background information on which this analysis rests:

- the initial survey and questionnaire data which identified the sample of teachers and informed the development work;
- the preliminary observations in classrooms which established a baseline for development work;
- a detailed report of an investigation of teachers' thinking about ICT and their teaching;
- a discussion about developing effective practice;
- a summary of some issues those wishing to undertake similar development may find helpful.

More detailed information about the research, data and analysis is contained in appendices.

Background

Primary teachers are currently undertaking a series of initiatives designed to support their professional practice and raise standards of attainment for their pupils through the National Literacy and National Numeracy Strategies. In addition, funds have been made available by the government through NOF to support training in the effective use of ICT in subject teaching for serving teachers over the next three years. It also must be acknowledged that this report on the current state of the use of ICT in primary schools is written at a time of intense activity and rapid change, when new equipment and resources are being made available to schools, in particular through the National Grid for Learning. It is targeted at the needs of teachers as support for them in their work with pupils in classrooms; to head teachers and IT co-ordinators as they plan to add

ICT to the repertoire of tactics and strategies for raising standards; to NOF training providers and those supporting professional development more broadly; as well as to policy makers and the wider research community.

Context

The research was commissioned with the aim of helping practising teachers in existing classrooms tackle particular teaching and learning issues in literacy and numeracy with the aid of ICT. It therefore reports on how existing technology, already commonly available in schools, can support this goal in a manner which is consistent with the National Literacy and Numeracy Strategies. In this area there is always the risk of new equipment becoming obsolete the day after it is bought. Our intention is to describe effective pedagogy with ICT, which we believe may have a longer 'shelf-life'. Finally we end this introduction with a deliberate misquotation, "educational research may be a science, but development work an art", or another (also misquoting Bismarck) "development work in education is the art of the possible".

Summary of the report

Overall findings

ICT offers the potential to improve standards of attainment in literacy and mathematics. In making effective choices about when, when not and how to use ICT to strengthen their teaching the crucial issue is how teachers can harness ICT effectively. This project identifies a range of factors which teachers need to take into account. These factors include:

- clear identification of how ICT will be used to meet specific objectives within subjects of the curriculum to improve pupils' attainment;
- ensuring that pupils have adequate ICT skills to achieve those subject specific objectives;
- a planned match of pedagogy with the identified purpose of ICT activities and learning outcomes *(e.g. by the use of ICT to demonstrate or model learning by a teacher or pupil)*;
- finding appropriate starting points for development for particular teachers in accordance with their teaching styles and approaches;
- adequate access to, and intensity of use of, the necessary equipment by pupils and teachers;
- effective technical back-up and support to overcome any difficulties encountered *(e.g. for printers on networks)* and the provision of adequate resources *(including apparently trivial issues such as supplies of ink cartridges)*.

The project team worked with a sample of teachers known to be achieving either average or above average gains on measures of relative pupil attainment. The teachers were supported in developing their practice in literacy and numeracy using ICT. The teachers were involved in deciding the specific focus for development. This was to ensure that the development work had clear literacy or numeracy teaching objectives and was contextually and personally appropriate.

Part of the development work involved an exploration of the links between teachers' thinking their teaching behaviours or actions in the classroom and pupils' learning gains. This work indicated that a key feature of the more effective teachers was their use of effective explanations. Teachers who favour ICT are likely to have well-developed ICT skills and to see ICT as an important tool for learning and instruction. They are also likely to value collaborative working, enquiry and decision-making by pupils. Teachers who have reservations about using ICT are likely either to exercise a higher degree of direction or to prefer pupils to work individually.

The final phase of the project was focused on teachers' development. The work on teachers' thinking and actions demonstrated the importance of taking into account the their preferences and beliefs about teaching as well as their attitude to ICT. In this final phase, pupils made significant gains on standardised tests in 14 out of the 16 development classes. In numeracy the overall average improvement was 2.8 months progress per month. The average improvement in literacy was 5.1 months per month. These tests were used to provide contextual evidence for the development work and do not *prove* that the gains were made as a result of using ICT. However, the gains made indicate that teachers can raise levels of pupils' attainment when they use ICT to support their teaching in literacy and numeracy and have clear objectives for each subject.

The work on teachers' thinking, classroom interactions and pupils' learning also indicated that a general factor of effectiveness may link enthusiastic and challenging teaching with teachers taking up new ideas and acquiring new skills (such as those required for the effective use of ICT). However, there may be limits to the range and complexity of classroom activities that can be effectively managed.

See Sections 2, 7 and Appendix 6 for further details of the work in classrooms and the pupil outcomes.

The work on teachers' thinking is described in Section 5 and Appendix 4 .

The research and development work

The research was conducted using a range of methods which included identifying a sample of teachers using relative performance or 'value-added' data from the Performance Indicators in Primary Schools project (PIPS) and survey data to establish degrees of use of ICT in the classroom.

A series of classroom observations was conducted with these teachers. The aim was to provide secure evidence of existing practice on which to base subsequent development work. Teachers were interviewed and aspects of their thinking about teaching and learning were investigated.

The project team then undertook intervention-focused development work with groups of these teachers. A range of methods was used to track and evaluate these interventions with the teachers, including the use of standardised tests. The development work aimed to explore and support teachers' choices in deciding when, when not and how to use ICT to support literacy and numeracy.

See Section 1 for an overview of the project and sources of data. Appendix 1.4 contains further details about PIPS.

Illustrating the development of effective practice

Knowledge of a number of factors underpinned the development work. Teachers' subject knowledge, teachers' ICT skills and the role of pupils' ICT skills were identified as potentially important.

The illustrations of effective practice presented in this report both encapsulate the development work and exemplify the TTA's framework of the functions of ICT across a range of year groups and specific learning objectives.

> See Section 2 for examples of the development work undertaken by teachers in the project.

The initial survey work

The project identified teachers by using information on their effectiveness from the PIPS project according to whether their pupils made either average or very good progress in literacy and numeracy compared with other pupils in the PIPS database.

A questionnaire was used to identify the extent of provision and use of ICT in those teachers' classrooms. Overall the reported provision and use of computers in the schools surveyed was low (a typical picture was one or two computers per classroom), though some schools had invested heavily in new equipment.

Patterns of use reported by primary teachers fell into distinct groupings which were similar in all the year groups surveyed:

- free choice activities for pupils;
- extension work as well as extra support for some pupils;
- use as a reward, or 'filler' for those who have completed other work;
- word processing, information retrieval (as with CD roms) and major project work - time-consuming activities that sometimes continued into break times;
- instructional use; for example, demonstration to the whole class or teaching how to use spreadsheets and databases.

There was some evidence that these patterns of use are changing as more equipment becomes available and as teachers implement new structures for teaching literacy and numeracy.

There was no clear link between reported provision and use of computers with pupils' progress in the data from the initial survey and questionnaires. However, at the extremes, schools reporting very high levels of use tended to be the more effective ones whereas schools reporting very low use were less effective.

See Section 3 and Appendix 1 for further details.

Key messages from existing evidence and research

In considering how the teaching of literacy and numeracy might be extended by the use of ICT, an important starting point was to identify research evidence about where ICT has the capacity significantly to enhance teaching and learning in classrooms. The current research literature suggested three key areas:

- the capacity to present or represent ideas dynamically or in multiple forms *(e.g. showing word endings joining in a slide show presentation, zooming in on a dynamic number line or comparing numerical data in tables with a graph of the same data)*;
- the facility for providing feedback to pupils as they were working *(e.g. through text-to-speech or by checking pupils' responses in a mathematics program)*;
- the capacity to present information in easily changed forms *(e.g. editing text in a word-processor or updating information in a spreadsheet).*

Some of these areas were shown in this project to offer clear potential for further development.

See Section 2 and Appendix 2 for further details of the evidence base and the way it was used in the project.

The preliminary observations

The purpose of the observation data was to establish a base line for development work. However the data also offered potentially helpful insights into effective teaching more generally. Some tentative links were found between the observations and the value-added data. Some of these were not consistent either between year groups or across observations. This reflects the inconsistency in the wider research literature about observable behaviours and pupil attainment and the small size of the sample of teachers observed in the project. A key feature of the more effective teachers in the project was that they used examples and counter-examples when explaining to pupils, and that they modelled and demonstrated work to groups or the class (e.g. by giving examples of words ending in *-ly* which are and which are not adverbs or by giving examples of numbers which are and are not even). They also used pupils to model and demonstrate what to do or what they had learnt in lessons (e.g. a Reception pupil touch counting accurately on screen for the benefit of other children in the class). This aspect of their teaching was also evident in activities which did not involve ICT.

The project team believe that this reflects knowledge of their pupils as well as a detailed understanding of the specific subject objectives being taught.

See Section 4 and Appendix 4 for further details about the observations in classrooms. Appendix 1.4 has information about PIPS.

Relating teachers' thinking and practice

The project team undertook a series of activities designed to explore teachers' thinking and choices about teaching and learning in primary classrooms. The aim of this was to provide information about the teachers and their teaching which would help to support the analysis and conduct of the development work.

Significant patterns emerged in the project teachers' ways of thinking which were internally consistent. Further significant patterns emerged when their ways of thinking were related to data from the observations, the questionnaire and the relative performance data about pupils.

No single aspect of teachers' thinking emerged as a clear indicator of 'value-added' pupil learning gains. However a combination of preferring subject-based to topic-based teaching and more active learning linked with the frequent use by the teacher of examples and counter-examples proved to be a reliable indicator of effective pedagogy in both literacy and numeracy.

Professional development initiatives to promote the effective use of ICT need to take account of the diversity of teachers' thinking and existing practice if they are to find appropriate 'hotspots' for development.

See Section 5 and Appendix 4 for further details about the thinking and practice of the teachers in the project.

Supporting the development of effective practice

Development work to improve effectiveness in teaching needs to take account of a number of areas addressed in the research literature about teaching and learning. ICT adds a further level of complexity to this process of change.

The development work with teachers in this project took account of a range of sources of information and worked with teachers pragmatically to support their choices about when, when not and how to use ICT in their teaching. This process involved negotiation, support, and feedback over an extended period. The forms of support offered to teachers for the specific subject, and ICT activities selected as a vehicle for development need to take account of the range of preferences, knowledge and skills which contribute to the effectiveness of individual teachers.

Professional development and training in ICT also has the potential to support development in specific subject areas.

See Section 6 for further details about the approach to development of more effective teaching.

Section 1: An Outline of the Project

The aims of this section are to:

- **provide a broad overview of the project;**
- **identify the aims and scope of the research;**
- **describe the main sources of data.**

The research was initiated because the Teacher Training Agency (TTA) is committed to improving the standards of pupils' achievements and the quality of their learning through improving the quality of teaching, raising the standards of teacher education and training, and promoting teaching as a profession. As part of this work the TTA commissioned the University of Newcastle to undertake research into effective classroom pedagogy using Information and Communications Technology (ICT) in primary schools. It is intended that this research will help teachers raise pupils' achievements by extending and enhancing their pedagogy through increasing their capacity to make informed choices about when, when not and how to use ICT in their teaching, and to understand the implications of using this technology.

1.1 The research aims

The specific aims of the project were to:

- test and develop a generic framework of the functions of ICT, highlighting the potential benefits and pitfalls in using ICT in classrooms, particularly in the areas of literacy and numeracy;
- help teachers raise pupils' achievements in these areas through supporting informed choice about such use of ICT in the classroom;
- refine and illustrate specific aspects of the framework through detailed classroom case studies of effective teachers' practice and development.

1.2 The research approach

We started by identifying classes where pupils made expected and higher than expected learning gains. We then identified a sub-sample of teachers in both categories who were making average and intensive use of ICT. Next we observed their teaching to validate the selection process and to provide contextual evidence to support later development work. We investigated some aspects of teachers' beliefs, subject knowledge and their approach to teaching. These data then provided an analytic framework for development work and a formative tool for shaping the development. The final stage of the project was to support, analyse and record the process with teachers from all of the categories as they worked on different aspects of literacy and numeracy teaching. This was in order to evaluate the development of different strategies for using ICT in their teaching.

Survey

The research was carried out in three main stages. During the first stage, a range of teachers was identified and the extent of ICT provision and use in their classes was determined through survey and questionnaires. The teachers were identified by the Performance Indicators in Primary Schools project (PIPS), based at Durham University, which collects value-added performance data on pupils that can be compared across schools. (For further information about PIPS please see Appendix 1, section 4.) The initial survey received 2053 responses (66% return rate) and the detailed questionnaire 250 responses (34% return). The project focused on teachers in Reception, Year 2 and Year 4 because of the year groups from which data are collected in the PIPS project. Although data are available for Year 6 it was felt that teachers would find it difficult to undertake development work in the summer term alongside National tests and transfer arrangements to secondary schools. The data from PIPS were central to the identification of teachers in this study. Teachers were selected on the basis of the relative performance of their pupils and their responses to the questionnaire which indicated provision, use and to some extent attitude to using ICT. At this stage of the project, names of teachers were passed on to the Newcastle team 'blind', so that observations could be conducted without being influenced by the data about the teachers' effectiveness. The teachers identified fell into two categories, average or high, in relation to the performance from the PIPS project. This was because the team wished to identify any factors that might distinguish teachers whose pupils make expected progress from teachers who produce extremely good gains with their pupils and can be considered (on the basis of their PIPS results) highly effective. These teachers came from schools in Gloucestershire, Lancashire, the West Midlands and the North East. (For more details please see Appendix 4)

Observation

In the second stage of the project four lessons taught by each of these 32 identified teachers were observed and the teachers were interviewed for three main purposes:

- to confirm that the information used to identify the teachers was accurate;
- to establish a baseline of observations before any development work took place, (particularly as regards use of ICT); and
- to identify particular pedagogical factors and aspects of the teachers'

choices in deciding when, when not and how to use ICT which might be linked with increased pupil attainment.

The project had established that there was little information in the literature about how teachers generally use ICT, as opposed to how ICT can be used in an intervention, and therefore wished to establish how the sample of teachers in this study were using ICT at the beginning of the research project.

Development

This information, together with information from existing research on pedagogy and on ICT, was then used with a group of 20 of these teachers who were invited to undertake specific development projects for their own classrooms. The teachers decided whether they wished to focus on literacy or numeracy and identified particular teaching and learning problems which they wished to tackle. They then planned a specific intervention using ICT, with suggestions and support from the project team members, to try to raise the standards of pupils' achievements in specific areas of English or mathematics. Evidence for the effectiveness of this development work focused on the impact upon pupil attainment using standardised tests and criterion-referenced measures. These teachers were also involved in a series of activities designed to investigate their thinking about teaching and learning in general, and about the role of ICT in pedagogy in particular. The development teachers were observed again both during and towards the end of the development work.

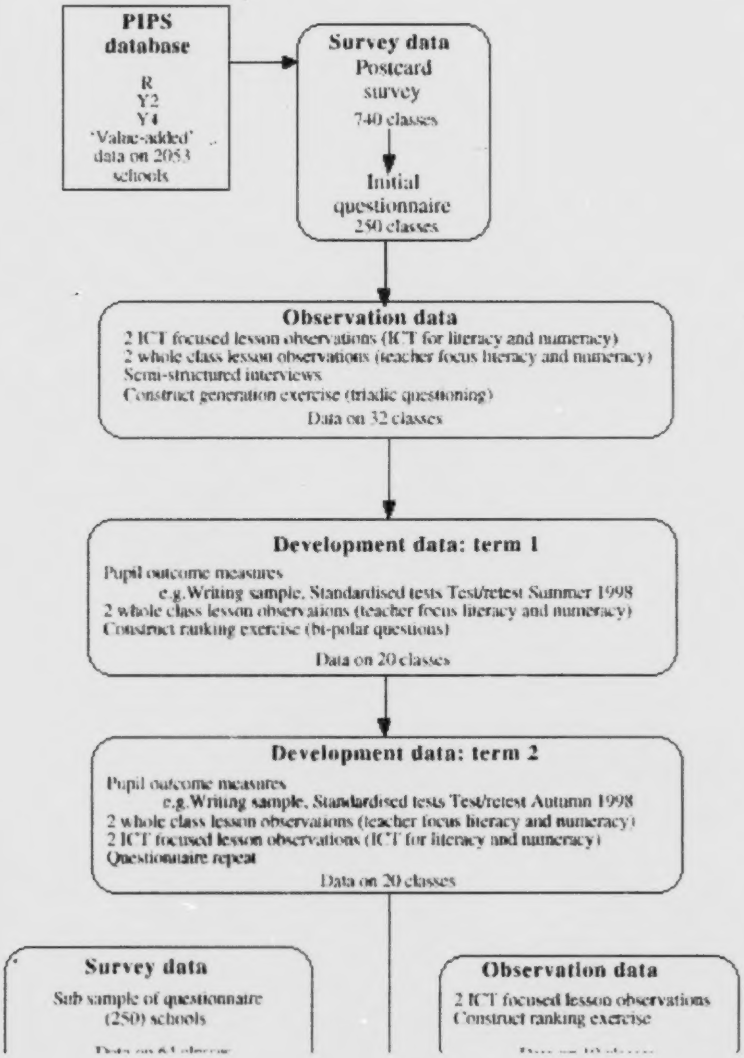
As part of the development work, a range of information was fed back to the teachers taking part. This included information from the observations, information about the pupils' results on the tests and the analysis of the work on their thinking about teaching and learning. This was done explicitly in the knowledge that it would influence the teachers' choices and behaviours and that this information, particularly about pupils' performance, could be used both diagnostically and formatively by the teachers in the development projects. As explained above, the aim of this project was to help teachers raise pupils' achievements through supporting informed choice about use of ICT in the classroom and to illustrate this through detailed classroom case studies of effective teacher practice and development. Existing evidence about how effective assessment information can be in raising attainment was therefore included as part of this process (e.g. Black and Wiliam, 1998).

Analysis

After the final phase of the project, all of the information gathered over the course of the survey, observation and development stages was analysed and used in producing illustrations of effective pedagogy for teachers. The illustrations are based upon these classroom data and they relate the development work to the functions of ICT which support effective pedagogy from the TTA framework.

A repeat questionnaire was conducted with a sub-sample of the initial 250 respondents and the development teachers to identify changes over the course of the intervening year (64 responses, 53% return rate). In addition, some of the data gathered about teachers' thinking and observed practice were analysed in relation to the relative performance data on pupils' attainment, as well as the overall findings from the development work in order to identify any links between teachers' thinking, behaviour and pupils' attainment. The development teachers were interviewed again at the end of the project. A diagram giving an overview of the project and the range of data is given below in Figure 1.1.

The scope and nature of this development project in using quantitative and qualitative data from survey, observation and interview, as well as data on pupils' attainment from PIPS and standardised tests to track pupils' improvement over the short term, makes it unusual. The main purpose of the quantitative data collected in this research was to provide a secure context for the development work and to ensure that the qualitative data gathered could be analysed within that context. The project was not designed as a statistically representative, quantitative study of effective teaching behaviours and pupil attainment. The funding and timescale did not allow for this. It was designed as a qualitative, large scale case study, grounded in quantitative data. The quantitative evidence has been used to validate aspects of the development work and is reported where it helps to elucidate specific aspects of the projects or some of the relationships between projects. The nature of the development work means that the particular teaching and learning objectives pursued in each of the classrooms were different. Any significant relationships between different aspects of the data were therefore considered in some detail by the project team as validating their informal observations and the experiences of the teachers themselves, rather than as an end in themselves.


PIPS database
R
Y2
Y4
'Value-added' data on 2053 schools
Survey data
Postcard survey
740 classes
Initial questionnaire
250 classes
Observation data
2 ICT focused lesson observations (ICT for literacy and numeracy)
2 whole class lesson observations (teacher focus literacy and numeracy)
Semi-structured interviews
Construct generation exercise (triadic questioning)
Data on 32 classes
Development data: term 1
Pupil outcome measures
e.g.Writing sample, Standardised tests Test/retest Summer 1998
2 whole class lesson observations (teacher focus literacy and numeracy)
Construct ranking exercise (bi-polar questions)
Data on 20 classes
Development data: term 2
Pupil outcome measures
e.g.Writing sample, Standardised tests Test/retest Autumn 1998
2 whole class lesson observations (teacher focus literacy and numeracy)
2 ICT focused lesson observations (ICT for literacy and numeracy)
Questionnaire repeat
Data on 20 classes
Survey data
Sub sample of questionnaire (250) schools
Observation data
2 ICT focused lesson observations
Construct ranking exercise

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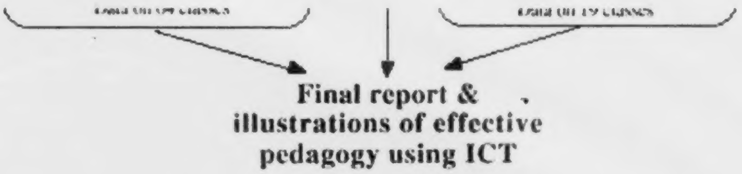
Final report &
illustrations of effective
pedagogy using ICT

Figure 1.1: The range of data in the project

The relationship between teaching and learning

The research team at Newcastle University are all members of the Learning and Instruction Group which uses a shared model of teaching and learning as part of it's collaborative work in understanding teaching, learning and the development of effectiveness. This model is used throughout this report as a way of exemplifying some of the complex relationships between teaching and learning and to present these relationships visually (Figure 1.2) to support the reporting of the development work.

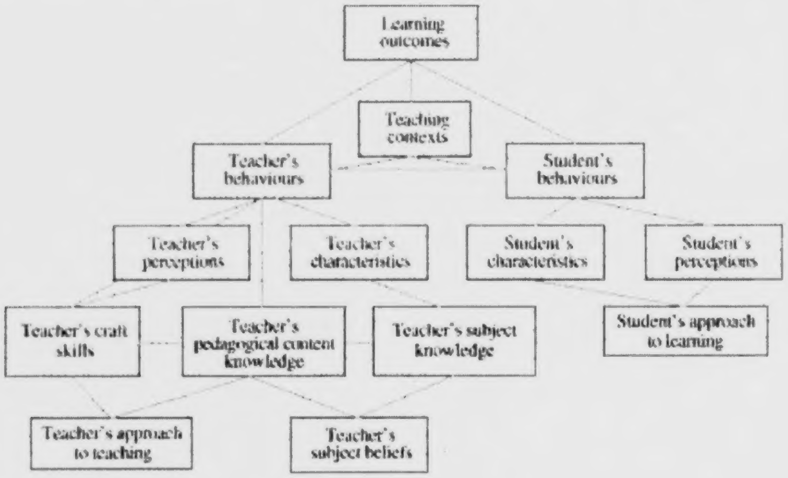
Learning outcomes
Teaching contexts
Teacher's behaviours
Student's behaviours
Teacher's perceptions
Teacher's characteristics
Student's characteristics
Student's perceptions
Teacher's craft skills
Teacher's pedagogical content knowledge
Teacher's subject knowledge
Student's approach to learning
Teacher's approach to teaching
Teacher's subject beliefs

Figure 1.2: An interactive model of teaching and learning

A key assumption of the model is that learning outcomes are directly influenced by the actions and behaviours of the teacher and the learners in a particular context. In other words, what a teacher does in a classroom and the way the pupils react to these actions or behaviours influence what they learn. These behaviours and the teaching context are what is directly observable in classrooms and this is represented by the top four boxes in the model. The interpretation of this interaction in a classroom is also influenced by the perceptions of the teacher and students and their individual characteristics. Each teacher or learner has a history of experience which influences their interpretations of classroom events. This might be in the way a teacher gives praise to a pupil and the way that this positive feedback is accepted (or rejected) by a pupil. The behaviour of teachers is also influenced by their decisions and skills in managing the classroom (or their 'craft skills'), their skills and experience in teaching particular skills and knowledge to particular age groups (sometimes called pedagogical content knowledge - see Appendix 3, for a fuller explanation), and their own subject knowledge of the content being taught. At a deeper level still, the presentation of this specific subject and pedagogical content knowledge is influenced by teachers' beliefs

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about the subject they are teaching and their overall approach to teaching. These underlying beliefs and approaches help to explain the day-to-day, minute-by-minute and second-by-second choices teachers make in the classroom.

This diagram simplifies the complexity and the interrelationships portrayed. The ideas behind the diagram are not original and the form of it here owes much to the work of other researchers (e.g. Schulman (1986), Biggs and Moore (1993), Gibbs (1995), Askew, Brown *et al.* (1997).

We believe that this diagram helps to illustrate aspects of the complexity in teaching and learning and can therefore be used to support an understanding both of what effective pedagogy might be and how teachers can be supported in becoming more effective. In the project we started by investigating how some of the aspects at the top of the diagram were related to teaching and learning and the provision and use of ICT in the classroom. The key features of the model as it applies to this project are the relationships between what the teacher does in the classroom, through to the underlying beliefs and approaches which influence the choices a teacher makes about what to do. The investigation in this project concentrates on the teacher's side of the model. This is not to imply that students' or pupils' behaviours and characteristics are not important. The development work aimed, however, to support teachers' choices in using ICT to support effective pedagogy and therefore focuses on the teachers, their actions or behaviours in the classroom and their knowledge and underlying beliefs influencing these actions.

In the next section we look at the main outcomes of the analysis of the project data and present illustrations of the work of the teachers involved in the project.

1.3 Specific outcomes

The outcomes intended for the project were as follows:

- a detailed report on the research and development work for the TTA;
- illustrations of research-based practice for teachers;
- a database of recent research on ICT in primary schools for use by the project team and the wider academic community;
- a website containing a research summary for teachers and researchers.

1.4 Summary

- **The research was conducted using a range of methods which included identifying a sample of teachers using relative performance data from PIPS, a survey, questionnaires and classroom observations. This identified a sub-group of teachers to take part in development work.**
- **A series of classroom observations were conducted with these teachers. The aim was to provide secure evidence for existing practice on which to base subsequent development work. Teachers**

were interviewed and aspects of their thinking about teaching and learning were investigated.

- **The project team then undertook development work with a group of these teachers and used a range of methods, including standardised tests, to evaluate pupils' progress and to track this with the teachers involved. This development work aimed to support teachers' choices in deciding when, when not and how to use ICT to support literacy and numeracy.**
- **A range of outcomes was planned to present the analysis and to disseminate the findings of the research and development project.**

Section 2: Describing and illustrating examples of effective pedagogy using ICT for literacy and numeracy in primary schools

The aims of this section are to:

- **review particular aspects of the development undertaken by the project as a whole;**
- **identify some key features and themes across the development projects;**
- **present examples of the development work undertaken in this project.**

2.1 Improving subject teaching through appropriate use of ICT

In most of the separate development classes standardised tests were used to measure pupils' progress and to provide detailed formative assessment information for the teachers. In the autumn term of the project 14 out of the 16 projects made significant gains on these tests (see Appendix 6 for further details). In numeracy the overall average improvement was 2.8 months per month. The average improvement in literacy was 5.1 months of progress per month. These tests were used to provide contextual evidence for the development work and do not demonstrate gains made as a result of using ICT. However, the gains made suggest that teachers can raise levels of attainment when they use ICT to support their teaching in literacy and numeracy. Similar gain was achieved by both groups of teachers, both high and average value-added (see Appendix 1 for further details). The evidence from the project indicates that development work to support teachers in making effective choices about when, when not and how to use ICT to meet their teaching objectives needs to take account of a range of factors.

Starting points

The project team found that teachers responded to different approaches to using ICT according to their individual knowledge, beliefs and approaches to teaching. For example, one school in the project already regularly used overhead projectors in each of the classrooms when working with the whole class. They easily adopted activities which were suited to this kind of presentation and were keen to explore the potential of an interactive whiteboard in their computer room. Other teachers preferred to develop effective use of ICT in group activities. Where a teacher had a strong preference for a particular approach or a subject this was found to be an effective starting point for developing more effective teaching with ICT. Success achieved in moving forward from the teacher's preferred starting point could then be used as a springboard for extending development into less familiar or less comfortable areas.

Teachers' confidence

Identifying a good starting point is clearly related to teachers' confidence and skills in using ICT. A teacher with more confidence and more advanced skills may be prepared to try a new teaching approach (such as using a presentation package with the whole class to share a text as part of a structured literacy lesson). A teacher less confident or skilful may be happier to experiment in a situation where they feel more confident (a discussion around a text, but with a group of pupils and perhaps involving a word-processor for shared writing, rather than less familiar presentation software). The project team found that more effective teachers tended to report higher levels of personal ICT skill and we believe that this reflects both their understanding of the potential of ICT and their determination to use it to support their teaching. Overall the teachers in the project had a wide range of competence in using ICT and it was necessary to identify individually appropriate starting points.

Focusing learning

Some of the illustrations which follow at the end of this section show how ICT can help teachers to focus pupils' learning. One example of this was a teacher who involved pupils in using multimedia software to create a teaching resource about apostrophes for other pupils to use ('Teaching the correct use of omissive apostrophes with Year 4 pupils'). Another teacher increased the pupils' attention on aspects of story-writing by planning stories and creating pictures with painting and drawing software ('Developing story-writing skills with Year 2 pupils'). The teacher's use of ICT as a presentational aid helps to focus pupils' attention during whole class teaching. One school used an interactive whiteboard in this way ('Using short rhymes and other texts to enhance reading comprehension'). A further example is a teacher who used presentation software in the literacy hour on a classroom computer in 'Presenting texts and supporting writing in Year 2'.

ICT can help to focus an activity in other ways; for example, by simplifying the process of data collection. In 'Developing understanding of decimals in Year 4', the ICT enabled two sets of decimal numbers to be produced easily which enabled the pupils to concentrate on ordering the numbers rather than on the process of collecting the information.

Another way to focus pupils' learning is by increasing access to ICT equipment and the amount of time spent using ICT effectively. In one school pupils had access to a suite of computers which the whole class could use once a week; in others portable equipment was used to increase the amount of access pupils had to ICT equipment on a daily basis.

Sustaining development

In all of the schools, sustaining effective development work was a challenge. Most of the teachers felt that there were already considerable demands on their time. Several factors affected how the teachers were able to maintain their momentum in using ICT to support more effective teaching and learning.

- The role of the head teacher in supporting such development work was one important factor. This might be only in terms of acknowledging it as a priority. Alternatively, some heads gave additional support to teachers in the project by providing extra resources or release time.

- The support of other colleagues in school was another factor which the teachers found helpful. The project team provided this support for some of the teachers in the project.

- Technical issues which arise need to be overcome quickly and effectively. This is particularly true in the early stages of any development work with ICT to ensure that sufficient benefits are achieved to encourage further development.

For each of the teachers there seemed to be a critical point of confidence and skill. Once this point was reached they were prepared to continue such development on their own. Not all of the teachers in the project reached that critical point. Even at the end of the project all of the teachers indicated that they would benefit from further support. This was related to developing their use of ICT in their teaching, as opposed to developing their own ICT skills, which a few of the teachers felt was their personal priority. Choosing software which can be used in different ways is also helpful. A teacher who has learned how to use the spreadsheet tools in an integrated package can more quickly learn how to use its data handling and graphing functions more efficiently. At the end of the project, the teachers who had been involved reported greater use of ICT for direct instruction compared with other teachers. They also reported changes in patterns of use reflecting a clearer focus on identifying where ICT could support their teaching of literacy and numeracy.

Planning for Subject Teaching

A clear distinction needs to be made between planning for pupils' IT capability (from the National Curriculum) and how ICT can support teaching and learning in other subjects. At the beginning of the project, most schools identified pupils' IT capability in their regular planning. Most planning did not specify how ICT could contribute to subject teaching, particularly where the teacher might use the computer (for example by presenting a text in the literacy hour).

Although most schools specified how they planned for IT capability, there was considerable variation in the observations of what pupils actually experienced as a result of this planning. Sometimes this was due to the limited amount of equipment available. In other cases, teachers ensured that the equipment that they had available was used very intensively. Some schools provided clusters of machines in designated computer rooms. Large groups or even whole classes could then be taught at the same time. Such arrangements were observed to be particularly efficient for teaching ICT skills to pupils and for supporting teachers in developing their own teaching skills in using ICT. Some of these schools had then moved on to providing more ICT resources in classrooms so that the teachers could plan to use ICT in different subject areas more effectively. Clear learning gains were achieved with different forms of organisation of ICT equipment used by the teachers in the project.

ICT and subject knowledge

The project found that development work in ICT can also be an effective way of developing teachers' subject knowledge in literacy or mathematics. One highly effective teacher, who had previously tried a range of strategies for teaching apostrophes to her class without success, undertook a series of activities which focused her attention on this challenging aspect of punctuation. Planning the multimedia activity enabled the teacher (and the pupils) to identify the rules and uses of omissive apostrophes in great detail, and the particular problems which the pupils had in applying those rules effectively. This helped her to focus on and understand a particular aspect of literacy teaching in more structured and systematic detail than had previously been possible. She may well choose not to repeat teaching apostrophes in the same way, with her new understanding she may be able to identify other efficient approaches in the future ('Teaching the correct use of omissive apostrophes with Year 4 pupils').

Similarly, a Reception teacher was able to devise a series of activities appropriate to the different levels of counting skill in her pupils. This enabled her to plan appropriate practice in different aspects of counting in accordance with the NNS Framework for Mathematics for Reception ('Developing counting skills in Reception').

Effective explanations

Another aspect of subject knowledge which the team found to be important was reflected in teachers' explanations. A key feature of the more effective teachers in the project was that they used examples and counter-examples when explaining to pupils and that they modelled and demonstrated work to groups or the class (e.g. by giving examples of words ending in *-ly* which are and which are not adverbs or examples of numbers which are and which are not even). They also used pupils to model and demonstrate what to do or what they had learnt in lessons (e.g. a Reception pupil touch counting accurately on screen to demonstrate co-ordination of touch and counting words). This aspect of their teaching was also evident in activities which did not involve ICT. The project team believe that this reflects knowledge of their pupils as well as a detailed understanding of the specific subject objectives being taught.

2.2 Supporting teaching in literacy and numeracy with ICT

The aim of the development work was to help teachers raise pupils' achievements in literacy and numeracy. As the project developed the emerging national literacy and numeracy strategies provided particular frameworks and specific teaching and learning objectives which the teachers supported with ICT. These frameworks were used by the project team and the development teachers to guide the planning of the specific content appropriate for pupils. In many cases the teachers were following guidelines for structured literacy and numeracy lessons and wished to incorporate ICT, where appropriate, to support these specific objectives. A number of key features of the development approach are reviewed here which we feel need further discussion before the presentation of the examples of development work at the end of the section.

Pupils' ICT skills and IT capability

Some of the teachers in the project, particularly those who were IT co-ordinators, and those who held the pro-ICT stance (discussed in section 5), identified pupils' IT capability (from the National Curriculum programmes of study) as an important part of their planning of any activities where the pupils were using ICT. This affected their choices about what kinds of activities they felt were appropriate to undertake as part of their teaching. The project team noted that where IT capability for pupils was involved it was particularly important to ensure that the development of pupils' ICT skills was not brought about at the expense of subject-specific objectives. The examples mentioned below for understanding word-wrap or using spreadsheets indicate how pupils' ICT skills need to be taken into account explicitly to ensure that the use of ICT is efficient as well as effective (discussed in Section 6). In the development work the team worked to ensure that pupils had adequate ICT skills to enable the subject-specific objective to be achieved This involved considerable time in supporting the introduction of new software and, in some cases, teaching skills directly to pupils.

Teachers' subject knowledge

Recent research on teaching effectiveness identifies subject knowledge and understanding as important components affecting how teachers perform in the classroom. (The reports commissioned by the TTA into effective teachers of literacy and numeracy (Medwell, Wray *et al.* 1998 and Askew, Brown *et al.* 1997) suggest how subject knowledge is related to effectiveness. Aubrey (1997) also has a useful summary of some of the research on subject knowledge in mathematics.)

In the project we used the TTA's literacy and numeracy Needs Assessment materials for Key Stage 2 teachers (mentioned above, Section 5.1) with the development teachers and asked them to rate themselves using the approach in the booklets. This provided an effective stimulus for discussing the role of subject knowledge as part of teachers' professional development. The feedback from the teachers was valuable. They felt that such materials were helpful where a teacher needed revision or support in teaching new content to pupils. Many aspects of the literacy materials covered content from the literacy framework. However, most felt that where they already taught such content the materials covered issues that they felt that they already knew and understood.

Teachers' confidence was a particular issue in this area. We considered that projects developing the use of ICT were already challenging, without directly assessing or testing specific subject knowledge, particularly in mathematics. The team had planned a supportive, collaborative approach to development. We therefore chose to address subject content (and pedagogical content knowledge) issues in the regular individual discussions and planning sessions for the project.

Project teachers' ICT skills and confidence

We describe in more detail below (Section 6) how teachers' skills and confidence in ICT were related to the development approach. The process of selection of the sample of teachers in the development phase meant that their existing expertise with ICT was not a factor which determined their inclusion in the project. While all of the teachers were keen to develop their skills, they had a wide range of skills and knowledge at the start of the project. The project team therefore took a pragmatic approach, as with subject knowledge, in addressing some issues as a group (where this was logistically practical) and in dealing with the development of other skills as necessary on an individual basis. The aim of the project was not to improve teachers' ICT skills directly, but to support them in the choices they made in deciding when, when not and how to use ICT to support their teaching of literacy and numeracy. In some projects this involved supporting teachers in acquiring new skills and abilities with ICT, in others the emphasis was more upon the application of existing skills and knowledge, or in relating existing skills to subject content.

Overcoming technical issues

As reported below (Section 6), there were some technical support issues in nearly every school. In most cases these were solved fairly quickly and the development work progressed unhindered. Occasional difficulties had a much greater impact on one or two of the schools, particularly where there were problems with networks which were outside the project's control. This meant that in one school an extra computer was supplied so that pupils could work in the classroom, and in two other schools slower than expected installation of connections to the Internet meant that the planned work could not be undertaken at all.

2.3 Relating the development work to the functions of ICT

The initial specification for the project included the development of a TTA outline framework of the functions of teaching and learning with ICT. Events superseded the completion of this work, as the TTA framework for ICT in Initial Teacher Training (DfEE 1998) was produced during the lifetime of the project. The work of the project team was used to inform aspects of the development of the framework. The functions of ICT which can be used by teachers in achieving subject teaching objectives and which are exemplified in the illustrations below are:

- speed and automatic functions;
- capacity and range;
- the provisional nature of information stored ('provisionality');
- the interactive way in which information is stored, processed and presented to provide rapid and dynamic feedback ('interactivity') which itself has further functions:
    - exploration of models and simulations
    - communication
    - searching and comparing
    - presenting information.

As noted above, this curriculum and the framework it contains also set the standard for the Expected Outcomes of the NOF training for serving teachers. The illustrations which follow serve both as a record of teacher development supported by detailed analysis of classroom practice through observation and assessment of learning gains and exemplification of these functions of the framework. There is one area in particular where the team feel that they can contribute to an understanding of this framework: this is in being clear about whether these particular benefits apply to teachers or pupils. The precise nature of the function that is helpful depends upon a clear identification of the particular benefit that ICT offers and whether this is from the perspective of teachers or pupils. The teacher can benefit from the *interactivity* and *provisionality* that a word processor offers when demonstrating a whole class text as part of a shared writing activity; the pupils can then make use of the provisional nature of the text in redrafting their work. In addition, the pupils can benefit from further features that this kind of software offers such as the *speed and automatic functions* in a spelling checker, or *interactivity* through *feedback* in a spelling checker which highlights words as they are completed that are not recognised in its dictionary.

The illustrations of effective development work

The examples of the development work which follow at the end of this section are presented as illustrations of effective practice which exemplify the choices about pedagogy which the teachers made. They are set in Reception, Year 2 and Year 4 classes. However, in one case a teacher developed the approach with a Year 3 class the following year and there was one mixed age class of Year 4/5 pupils.

The table below (Table 2.1) indicates the range of development projects undertaken. Not all of these produced sufficient data to draw upon for the illustrations, though all contributed to the analysis of teachers' thinking (Section 5) and development issues (Section 6). In particular the regular visits to and contacts with schools in the North East produced a greater range of information on which to base the illustrations. As expected, there were also some changes in schools which affected the development work. One of the teachers was promoted, one teacher withdrew through illness and one for personal reasons. Of the twenty development projects started, seventeen were completed with full sets of pupil and teacher data for both of the terms of development work. Nearly all of the projects achieved the objectives agreed at the beginning of the development phase. For some teachers it was hard to maintain a clear focus on the project in the second term when we had planned to provide less intensive support. In most cases the level of support was increased to nearly the level of the first term. Many of the teachers were implementing the National Literacy Strategy, either for the first time or using the revised framework, so developing ICT as well required considerable effort. In a few schools the development went well beyond what was planned; in each case this was where there was either clear support within school from the head teacher in particular, or where effective collaboration between staff took the work further than had been initially anticipated.

The table below shows the year group and subject focus for the development projects as well as the main teaching objectives. Headings in bold indicate that fuller descriptions of these 12 projects are included as illustrations at the end of this section.

	Literacy	Numeracy
Reception	Developing basic literacy skills: *Capacity and range / Interactivity*	**Developing counting skills** *Speed and automatic functions / Provisionality* Developing understanding of addition and subtraction: *Speed and automatic functions / Interactivity*
Year 2	**Presenting texts and supporting writing** *Capacity and range / Provisionality /Interactivity* **Improving reading and spelling** *Interactivity* **Developing story-writing skills** *Capacity and range / Provisionality*	**Teaching calculation skills** *Interactivity / Speed and automatic functions* Developing range of possible solutions & recall of number facts *Speed and automatic functions / Interactivity*
Year 4	**Developing writing skills** *Provisionality / Interactivity: communication* **Teaching the correct use of omissive apostrophes** *Speed and automatic functions / Provisionality / Capacity and range* **Reading challenging text with speech and dictionary support** *Interactivity* **Using short rhymes and other texts to enhance reading comprehension** *Interactivity / Provisionality* Developing writing skills (2 projects) *Provisionality / Capacity and range / Interactivity: communication* Effective information searching: *Capacity and range/ Interactivity: searching and comparing.*	**Developing understanding of decimals** *Speed and automatic functions / Interactivity* **Developing mental calculation skills through pattern in number** *Interactivity / Speed and automatic functions / Capacity and range* Developing mental calculation skills through pattern in number *Interactivity: presenting information* *Speed and automatic functions* **Supporting number skills** *Interactivity / Capacity and range* Improving numeracy skills with puzzles and problems *Interactivity: presenting information.*

Table 2.1: Mapping the projects onto the framework

The potential of ICT

A review of the literature about the use ICT in primary schools suggested a number of areas where it was likely that ICT could support pupils' learning. In literacy many of the research studies report benefits of speech on pupils' literacy skills (see Appendix 2, full references to the research and literature mentioned here are given there.) One of these areas was speech feedback in word processors used to improve reading and spelling, or speech in interactive storybooks, and more recently speech input to computers (where the spoken word is transcribed by the computer and appears on screen as written text). The combination of speech and text for pupils was therefore one area in particular which we thought would be beneficial for literacy in particular. The use of speech was pursued in most of the development projects in literacy in one form or another and the combination of spoken number name and numeral symbol was used in a Reception class where this facility was available with numeral 'stamps' in a painting package to support numeral recognition.

In mathematics the research evidence for the impact of ICT on pupils' attainment was less convincing, though again there were specific examples which suggested ICT could be beneficial. One of the inferences we drew from this research base (for both literacy and numeracy) was that ICT was powerful in presenting or representing information in different ways. This might be through speech and text, or text and pictures for literacy and pictures and numerals or tables and graphs for numeracy. The challenge for the project was how to exploit this facility in particular areas of literacy and numeracy teaching.

ICT clearly also has potential to represent information more dynamically than on paper. This might be helpful in that the learner can make changes easily and evaluate the effect of those changes in one representation (e.g. considering changes in a text as part of the redrafting process or investigating changes in a formula in a spreadsheet). Such changes can also be investigated *between* different representations. In this case the aim would be to support pupils' understanding of the information being manipulated (such as identifying changes in a graph when changes are made to a table of numerical information on which the graph is based). The dynamic nature of ICT was exploited by one teacher in the project who used a presentation software package. She created a series of slides where word endings joined word stems on screen (e.g. *reach* + *-ed*) which the pupils read as the words were presented. This approach using changes on screen also underpinned the development work in one of the mathematics projects in developing pupils' understanding of number through examining patterns on a computer ('Developing mental calculation skills through pattern in number in Year 4').

Our overall conclusion from the research literature was that ICT had the potential to support the teaching of literacy and numeracy, but that there was a range of factors to take into consideration if the inclusion of ICT was to support pupils' learning.

Systematic use of ICT

The project team looked at pupil learning gains where teachers reported systematic use of ICT and where they did not. There was no evidence of a link between pupils' learning gains and such use. We became increasingly aware of the constraints under which schools and teachers are working. All the teachers involved in the project, including those who were identified as intensive ICT users, could find only limited time when pupils could use computers to improve their literacy or numeracy (typically about half an hour a week each). Furthermore, although amount of ICT equipment in schools increased during the life of the project, much computer use in primary classrooms was planned as an addition to the curriculum rather than as a key teaching strategy. This was reflected in the low use of ICT for direct instruction generally and by the average provision of one or two computers in a typical primary classroom. Teachers in the project reported a greater use of ICT for direct instruction at the end of the project. This suggests that more focused and effective use of ICT can be developed to support subject teaching.

Teachers and trainers who want to use ICT effectively to support teaching designed to raise standards need to consider the range of different ways in which teachers can use ICT. These strategies should be an integral way to meet teaching objectives, such as using ICT for direct instruction, for example.

Pupils' ICT skills

Children have to be taught how to use the technology or software before they can make effective use of ICT. This basic first step can be a big challenge for teachers as it takes time and may not have a clear literacy or mathematics focus.

Emphasising this issue so that teachers can take it into account is essential. For example, when using timing software connected to a pressure mat to produce times in seconds with two places of decimals required some direct teaching of how to use the equipment before the pupils could engage with the mathematics. The teacher had to decide whether this was an efficient use of both her time and that of the pupils ('Developing understanding of decimals in Year 4'). Similarly in teaching redrafting on a word-processor pupils need to know not to press the return key at the end of each line and have an understanding of 'word-wrap'.

The teachers in the project found it necessary to:

- identify clearly what skills the pupils needed in order to benefit from using the computers in the areas of literacy and numeracy they had targeted;
- ensure that the pupils' skills were adequate so that pupils could concentrate on the specific subject objectives.

In the project teachers used time on clusters of machines in school, or at a local ICT centre or the University to ensure that pupils knew how to use the software so that teaching in literacy or mathematics sessions could focus on the subject specific objectives. This issue of pupils' ICT skills proved to be one of the most significant themes across the projects. The teachers in the project needed to consider whether the time taken developing ICT skills was an efficient use of their teaching time.

2.5 Key features and themes in the illustrations of effective practice

The illustrations of effective use of ICT

The illustrations included in this section all have a wealth of supporting information. They can be read alone: for example, by a teacher who wants to tackle a particular aspect of mathematics or literacy teaching; or as part of a series, by a teacher who wants to explore how to integrate ICT into subject teaching more generally. Amongst

the features the illustrations contain are:

- **descriptions of the schools, the teachers and the pupils involved;**
- **what the aims were in terms of specific literacy or numeracy objectives;**
- **accounts of the teachers' choices about how to achieve these aims;**
- **information about developing the approach, including any improvements made;**
- **an account of the obstacles encountered and overcome;**
- **brief summaries of the key features of the development work;**
- **suggestions for further reading particularly relevant to the subject-specific objectives in the illustrations.**

2.6 The illustrations of effective pedagogy with ICT in numeracy

A range of development projects was undertaken where teachers had chosen to focus on improving pupils' attainment in numeracy. In each case the work undertaken by the teachers supplemented or developed specific aspects of numeracy. The activities were therefore designed to support pupils' work in other related activities.

The development projects in numeracy reported below are as follows:

Developing counting skills in Reception

Speed and automatic functions / Provisionality

Teaching calculation skills in Year 2

Interactivity / Speed and automatic functions

Developing understanding of decimals in Year 4

Speed and automatic functions / Interactivity

Developing mental calculation skills through pattern in number in Year 4

Interactivity / Speed and automatic functions / Capacity and range

Supporting number skills in a Year 4/5 classroom

Interactivity / Capacity and range

These illustrations show how teachers have used ICT to support the attainment of specific teaching objectives in mathematics across a range of year groups and with a range of equipment. In most cases the activities were planned to focus pupils' attention on the specific aspects of number being taught. (e.g. 'Developing understanding of decimals in Year 4'). The use of ICT enabled the teacher to get the pupils to understand two different types of decimal times in seconds which they produced by timing their own physical performance.) The equipment simplified the timing process so that the pupils could focus on the mathematics involved in ordering the times. In one activity the smallest time was 'best', in another it was the longest time. Similarly, the Reception teacher was able to use the facilities in a painting program to target more demanding aspects of early counting skills based on her assessment of her pupils' level of skill and understanding.

2.7 The illustrations of effective pedagogy with ICT in literacy

Many of the themes apparent in the numeracy illustrations are evident in those that follow for literacy. Teachers used ICT as part of a broader range of strategies and approaches. A number of year groups and a range of equipment is covered. One prominent theme that runs through a number of the development projects is the use of the text-to-speech facility available in a range of software. The preliminary surveys and observations conducted in the project indicated that although most schools had such software, the text-to-speech facility was rarely used. Teachers in the project used it in various ways to support reading, spelling and redrafting as well as to enhance reading comprehension. This is an example of how ICT can be used to represent information in different forms. Written text on screen was then spoken to support different learning objectives (e.g. in 'Improving reading and spelling in Year 2' or 'Reading challenging text with speech and dictionary support' and 'Using short rhymes and other texts to enhance reading comprehension'). The computer supported pupils' literacy skills by presenting words and text visually and aurally. The development projects in literacy reported below are as follows:

Presenting texts and supporting writing in Year 2

Capacity and range / Provisionality /Interactivity

Improving reading and spelling with speech feedback in Year 2

Interactivity.

Developing story-writing skills in Year 2

Capacity and range / Provisionality

Developing writing skills in Years 3 and 4

Provisionality / Interactivity: communication

Teaching the correct use of omissive apostrophes in Year 4

Speed and automatic functions / Provisionality / Capacity and range

Reading challenging text with speech and dictionary support in Year 4

Interactivity

Using short rhymes and other texts to enhance reading comprehension

Interactivity / Provisionality

Other projects look at how ICT can help increase the intensity of pupils' learning, such as using multimedia to create a teaching resource about apostrophes for other pupils to use ('Developing the correct use of omissive apostrophes in Year 4') or increasing pupils' focus on story-writing through planning stories by creating pictures with a drawing package as part of the process ('Developing story-writing skills in Year 2'). The teacher's use of ICT as a presentational aid can support this intensity by focusing pupils' attention in whole class teaching (for example with an interactive whiteboard in 'Using short rhymes and other texts to enhance reading comprehension' or using presentation software on a classroom computer in 'Presenting texts and supporting writing in Year 2').

Another aspect of this intensity of experience is provided by increased access to ICT equipment. In one school pupils had access to a suite of computers which the whole class could use once a week, in others portable equipment was used to increase the amount of access pupils had to ICT equipment on a daily basis.

The range of projects

The projects covered a range of teaching and learning objectives across the primary age range. As we had expected a range of support issues was encountered across the projects (see Section 5 below). The technical issues we had predicted were easiest to overcome where there was local support available (either through the team locally in the North East, or where there was good technical back-up for an individual school). In many of the projects the ICT provided a focus for subject-specific discussions between a project team member and the teacher concerned or for discussions relating to craft knowledge or more general aspects of teaching and learning. Specific aspects of the teaching context also shaped the discussions and the course of the development work. As we discovered through the analysis of teachers' thinking, many of their choices were influenced by their underlying approach to teaching. The success of the projects (at least as indicated by the standardised tests) was due, we believe, to the increased focus the project gave to each of the specific areas of literacy or numeracy targeted and to the agreed process of development which tried to take into account the aspects of the model of teaching and learning discussed in each of the following sections of this report.

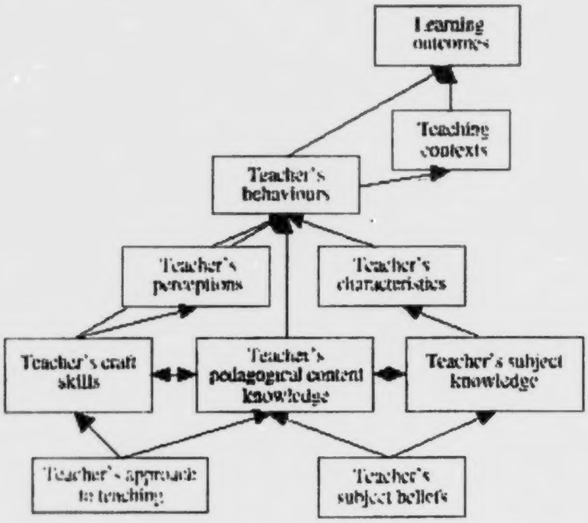
Learning outcomes
Teaching contexts
Teacher's behaviours
Teacher's perceptions
Teacher's characteristics
Teacher's craft skills
Teacher's pedagogical content knowledge
Teacher's subject knowledge
Teacher's approach to teaching
Teacher's subject beliefs

Figure 2.1: The model used to support the development work

2.8 Summary

- **The development work took into account a number of factors. Among these were awareness of teachers' subject knowledge, teachers' ICT skills and consideration of pupils' ICT skills.**
- **Statistically significant gains were achieved in nearly all of the development projects. These gains cannot be attributed to solely to ICT but nevertheless indicate that teachers can raise levels of attainment when using ICT to support their teaching of literacy and numeracy.**
- **The illustrations of effective practice both encapsulate the development work and exemplify the TTA's framework describing the functions of ICT across a range of year groups and specific learning objectives.**

Section 3: The Initial Survey and Questionnaire

The aims of this section are to:

- **outline the initial stage of the project and the process of identifying the schools and teachers who participated in the project;**
- **report some of the findings from the initial survey and questionnaire;**
- **identify some patterns of use of computers in primary schools.**

The remaining sections of this report outline the range of information gathered during the course of the project on which the analysis and illustrations rest. This section explains how the project started with survey and questionnaire data to identify a group of teachers for further investigation.

3.1 The initial survey and value-added data

The initial phase of the project involved administering a postcard survey and follow-up questionnaire. This was used to identify potential teachers and classes from within the PIPS sample of schools and to relate the relative performance data about their pupils ('value-added') with the availability of ICT equipment and its use. In addition, some of the information from the questionnaire was used to refine the detailed focus of the classroom observations and interview questions for the observation stage of the research.

Postcard survey of computer use

During the autumn of 1997 the Curriculum Evaluation and Management Centre (CEM) team at Durham University sent a postcard survey to all 2053 schools in the PIPS project which had pupils in Reception, Year 2 and Year 4. There was a 66% return rate to the survey. The postcard asked heads to estimate how often pupils used computers in Reception, Year 2 and Year 4. The results in percentages are given in Table 3.1 and graphically in Figure 3.1.

	Most pupils used computers						
Year Group	less than once a month	about once a month	about once a fortnight	every week	every day	more than once a day	total %
Reception	3	7	15	54	17	4	
Year 2	2	9	20	52	13	4	
Year 4	3	11	23	49	11	3	

Table 3.1: Reported computer use

By quite a long way, the most common response for all three year groups was that pupils used computers once a week. Most other responses were split between 'every day' and 'about once a fortnight' with very small numbers reporting use as common as 'more than once a day' or 'less than once a fortnight'. A pupil survey conducted in early 1999 found that Year 4 pupils broadly reported the same frequency of use of about once a week, though they estimated that they worked at the computer for slightly less time (see Appendix 1 for further details).

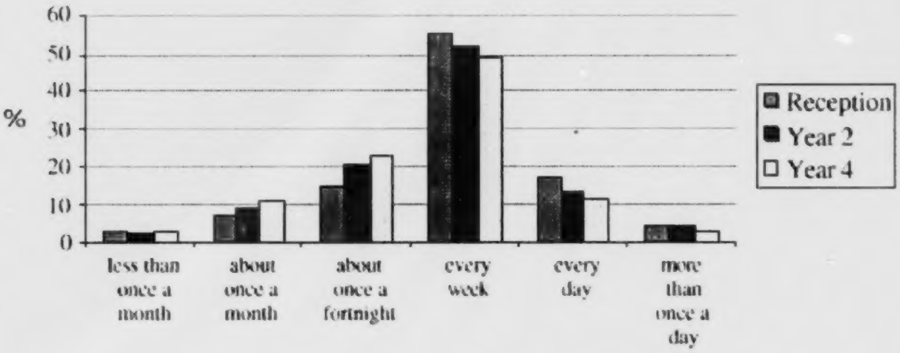

Figure 3.1: Reported computer use

There was a tendency for schools with a high use of computers in one year group to report a high use of computers in another. (The correlations were about 0.6 and although this indicates that schools which report high use of computers by one year group tend to report high use by other year groups, there are also many schools where this is not the case.)

Analyses were carried out to see if high computer use across a year group in a school was linked with high levels of achievement, high value-added scores, or very positive attitudes. Generally there was little evidence for this. There was almost no association between reported amount of computer use and either achievement level or attitude. However, there was a relationship with value-added in that the small number of year groups where pupils were said to use computers "more than once a day" had positive value-added scores on average. Year groups where pupils used computers "less than once a month" had negative value-added scores on average. This suggests that, at the extremes, highly effective teachers tend to have pupils using computers a lot and less effective teachers have pupils using them infrequently. The effect sizes between the high and low groups were moderate: 0.6 for mathematics and 0.4 for reading, with the most significant result applying to mathematics value-added in Reception classes. We can therefore state with some confidence that Reception teachers who are particularly effective in mathematics tend to use computers more often.

3.2 Questionnaire about ICT use and availability

The aim of the initial postcard survey was to get information quickly from schools so that we could select some of these to get further, more detailed information about how teachers used ICT. A more detailed questionnaire was subsequently sent out which included both quantitative and qualitative items. The main purpose of the questionnaire was to identify teachers and classes for further study in relation to:

- level of ICT provision;
- the degree of reported systematic ICT use; and
- the previous year's value-added scores in literacy and numeracy.

A subsidiary purpose was to gather information concerning the views and needs of teachers concerning ICT, in order to inform future development work in some of the schools.

The postcard survey yielded data for 740 classes for which 1996-7 value-added scores were available and from these 250 questionnaire returns were received (a response rate of 34%). A fuller report of some aspects of the findings from the survey and questionnaire can be found in Appendix 1.

Some findings from the first questionnaire

The following conclusions can be drawn from the questionnaire data:

- few classes had enough computers to fully occupy more than four pupils at a time;
- the memory limitations of older equipment (e.g. BBC computers or machines with less than 4 Mb of RAM) are such that about a third of the classes in the sample were severely restricted in terms of access to multimedia software;
- most classes had insufficient ICT resources to allow any pupil to check spellings or word meanings on demand during class written work;
- very few classroom computers had an Internet connection (4.6%);

- most classes had enough calculators for individual pupils to use in groups, and about a quarter had whole class sets;

- work with other ICT equipment such as turtles, Roamers and digital cameras was likely to be limited to class demonstrations or to use by one group at a time;.

- fax machines were rarely used by pupils as a means of communicating within or between schools.

So far as computer use is concerned, the questionnaire broadly confirmed the findings of the postcard survey, in that the most common pattern was that teacher reported that their pupils worked on a computer once a week, for between 15 and 30 minutes (increasing from 15 minutes in Reception, to 20 minutes in Year 2 and 30 minutes in Y4). Only 12% of pupils worked on a computer for an hour or more each week. Computers were generally in use every day, or else several times a week.

Factor analysis showed that computer use tended to fall into four or five patterns, which were similar in all year groups. These were (in rank order):

- free choice activities for pupils (*this was very common, especially at KS1, where it would often include number work or practice of basic skills*);
- extension work as well as extra support for some pupils (*this type of use was most often seen in Reception, happening daily in about one in four Reception classes*);
- use as a reward, or 'filler' for those who have completed other work *(this was typically a fortnightly occurrence in all year groups*);
- word processing, information retrieval (as with CD roms) and major project work - time-consuming activities that sometimes continued into breaks (*this tended to happen about once a fortnight, but more frequently for older pupils*);
- instructional use of ICT; for example, demonstration to the whole class or teaching how to use spreadsheets and databases (*this was the least common type of use, but it did show a slight increase with the age of pupils*).

Teachers of older pupils were less likely to use the computer as a reward or to fill in time and more likely to use computers for word processing, information retrieval or project work.

Generally, the teachers had positive attitudes towards ICT, with 96% agreeing with the statement 'I think my pupils like to learn with computers', 72% saying 'I am keen on the educational use of ICT' and 58% believing that there were not enough computers available for the needs of their class. Those with an overall positive attitude were significantly more likely to use computers to demonstrate something to the whole class and to have pupils using computers at break times, for major project work and for word processing. However, only 22% of the respondents were willing to say that 'Computers make me feel good about my teaching', with 30% unsure and 48% disagreeing.

Finally, it must be recognised that those who returned the questionnaires were a sub-sample of a sub-sample and may therefore have been more interested in ICT than most teachers. It is therefore worrying that so few felt that ICT enhanced their teaching: certainly more (48%) agreed with the statement 'Teachers do not need to use ICT to be effective' than disagreed with it (33%). The following list identifies other factors where the majority view was on the negative side:

- delays in fixing equipment that has broken down;
- insufficient information in school about educational software;
- difficulty in monitoring pupils' learning on computers;
- difficulty in planning follow-up work for computer activities.

This information was helpful in planning the development work in schools, particularly in giving an overall view of the level of provision and patterns of use. It also gave some indication of areas where the project team needed to plan to ensure that support would meet teachers' needs.

Identifying classes for further study

The main purpose of the data from this questionnaire was to identify teachers for the next stage of the project. It enabled Durham University to contact specific teachers where they had information about their effectiveness and then further information about their reported ICT use with their classes. These teachers came from four main geographical regions: Gloucestershire, the West Midlands, Lancashire and the North East. The clustering of sites was partly to facilitate the logistics of the research, but also reflects the distribution of schools involved in PIPS. At this stage of the project the Newcastle team were not informed about the value-added data for individual teachers. This was to ensure that in the next stage of the project the observers would be working 'blind' so that the information about the relative performance of pupils would not influence the observations.

Teachers in one of the identified groups were all achieving at least average gains as measured by PIPS, while those in the other group were obtaining well above average gains ('high value-added'). The team chose to work with teachers in these groupings for two main reasons. First we wished to see if we could identify any factors which distinguished teachers whose pupils make average progress from teachers whose pupils make very good progress. Research so far conducted tends to distinguish between 'more' and 'less' effective teaching. We wished to investigate what it is that highly effective teachers do as this seems likely to help a greater proportion of teachers. The second reason was an ethical one in that we wished to discuss with the teachers the information about the relative performance of their pupils and considered that there were difficulties in making this kind of information public in the course of the research if we were comparing two extremes.

The model of teaching and learning

In terms of the diagram introduced above (Figure 1.2), we have considered how specific teaching contexts with ICT provision and use are related to learning outcomes (as measured by PIPS), and we have identified our teachers on the basis of these two sections of the model.

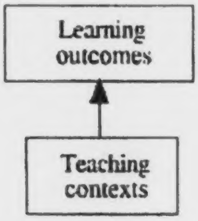

Figure 3.2: Teaching contexts and learning outcomes

3.3 Summary

- **The project identified teachers by using information on their effectiveness from the PIPS project according to whether their pupils made either average or very good progress compared with other pupils in the PIPS database.**
- **A questionnaire was used to identify the extent of provision and use of ICT in those teachers' classrooms.**
- **Overall, the reported provision and use of computers in the schools surveyed was low (a typical picture of one computer per classroom), though some schools had invested heavily in new equipment.**
- **Patterns of use reported by primary teachers fell into distinct groupings which were similar in all the year groups surveyed.**
- **There was no clear link between reported provision and use of computers and pupils' progress. However, at the extremes, schools reporting very high levels of use tended to be the more effective ones and schools reporting very low use were less effective.**

Section 4: Observing what happens in classrooms, with and without ICT

The aims of this section are to:

- **report on the initial observational work in the classrooms of the teachers who were identified for further study;**
- **describe the rationale for the observations;**
- **report findings from these observations.**

4.1 Introduction

The project team considered this observational work a central part of the research design.

This was partly to validate the information gathered through survey and questionnaire as well as to sharpen the focus of the development phase. The aim of the project was to identify teachers' pedagogic choices. This involved understanding three main questions *what do they do?* , *what thinking informs their practice?* and *what influences their choices and actions?* In addition the team was aware from the literature that there is little information about how ICT is used in classrooms by teachers and pupils who are not part of a specific project or who are not undertaking development work in this area (see Appendix 2 for a summary). Even where such information is reported, there is little evidence about the impact of ICT on pupils' attainment. The observations also enabled us to establish a baseline against which to compare subsequent observations so that we might identify the impact of our development work. It also provided information about each teacher separately for private discussion as part of the development work (see section 6 for further details). The value-added data enabled the team to investigate any pedagogic factors or patterns of behaviour which might be linked to the relative performance of the pupils. As the team investigated these classrooms before this information was revealed, these first observations were an opportunity to explore such relationships. The development work with teachers was planned so that it would involve supporting the development of their practice in using ICT effectively to support literacy and numeracy. Evidence from the observation phase was identified as a part of this process. The evidence about how effective teachers use ICT was planned as a potential 'catalyst' for change in the subsequent development phase.

4.2 Observing in classrooms

Although the limitations of observational research of quantifiable behaviours in classrooms has been noted in the research literature there is evidence that quantifiable behaviours can be linked to pupils' progress (e.g. Brophy and Good, 1986) and can be used to support effective improvement (e.g. Slavin, 1987; Walberg, 1986). The research team therefore wished to gather observational data for (1) validation, (2) to provide evidence of effective practice in ICT and (3) to feed back this evidence to teachers to support their development. (A fuller account of the literature on effective pedagogy and the way this influenced the design of the observational instruments and techniques in this project can be found in Appendix 3.)

4.3 Findings

The team found significant links between the 'value-added' of the relative attainment of their pupils from PIPS and our classroom observations and questionnaire data. This has provided us with direct observational evidence from the teachers we worked with which relates what we observed to what we know about the relative performance of their pupils. The intention was that this evidence about their practice could be used in the development process. The initial findings are summarised in the following section. The team tried to identify significant relationships which distinguished the highly effective teachers from those whose value-added scores were about average. In addition we looked for patterns concerning the use of ICT and the teachers' effectiveness.

The findings from the classroom observations are grouped by the common features of lessons, teacher behaviours and pupil behaviours. These relate directly to the observations we conducted. Some findings are tentative because of the sample size in this study. We were able to use the value-added data about overall effectiveness from the year before the project started (1996-7) which helped to identify the sample. We then updated this with specific information about each teacher's effectiveness in mathematics and reading separately for the year in which the observations were conducted (1997-8). We report below significant links between the observations and the value-added data from PIPS for both sets of value-added data. Findings statistically significant for both sets of data are given in bold. The differences result from using two separate sets of relative attainment data on the pupils. Though the findings are supported by the overall patterns of results (i.e. the correlations are similarly positive or negative), in such a small sample statistical significance is hard to attain.

Features of lessons

> Teachers with high valued added scores from PIPS tended to have orderly transitions (e.g. from whole class to group work) (1996-7 data) .
>
> These highly effective teachers had a high proportion of pupils on-task in numeracy and English lessons (1996-7 data).
>
> Highly effective teachers tended to have more groups in mathematics (linked particularly with mathematics value-added for 1997-8).
>
> Highly effective teachers tended to have longer plenary sessions in English (1996-7 data). **This was particularly significant for Reception classes** (1996-7 & 1997-8). *(Plenary sessions tended to be longer in English lessons overall, possibly reflecting the growing influence of the literacy hour model at the time the observations were conducted in February and March 1998.)*

Teacher behaviours

> **Highly effective teachers used more examples and counter-examples in numeracy lessons. For example a teacher would give an example of an incorrect solution as well as a correct solution and explain why one was correct and the other incorrect (1996-7 and 1997-8).** *(This was a particularly strong relationship and suggests that effective teachers use examples as part of their teaching but also exemplify what they are teaching with counter-examples for clarification.)*
>
> Highly effective teachers tended to give a relatively higher rate of praise in English lessons (1996-7 data and positive but non-significant with the 1997-8 data).
>
> Highly effective teachers tended to provide different ICT activities for pupils with SEN from those for the rest of the class (1996-7 data) **particularly in Reception** (1996-7 & 1997-8 data).

Pupil behaviour

> **Pupils tended to model work in mathematics lessons as examples to their group or the rest of the class in the highly effective teachers' classes (1996-7 and 1997-8).**
>
> Pupils in the highly effective teachers' classes had higher levels of interaction

> with each other while using ICT (i.e. they talked more to each other more while they were working, not just about the task they were engaged in) (1996-7 data). *(Overall it seems that highly effective teachers allow or encourage more interaction with peers when one or more are using ICT. This interaction is sometimes task related or concerned with functional aspects of the ICT - for example when pupils help each other out in using the software, but it also includes some social exchanges, particularly in English focused sessions.)*

Class characteristics

> **High value-added teachers had more pupils in the room when observed.** *(Among the possible reasons for this finding it may be that highly effective teachers have fewer pupils withdrawn for support or a lower rate of absence.)*

Effective explanations

One area clearly distinguishes our highly effective teachers is their skills in explaining effectively to pupils. The observational findings relating to the teachers' use of examples and counter-examples as well as their behaviours in modelling work to pupils in whole class and group teaching exemplify this. In addition they are more likely to involve pupils in explaining and modelling to the class or to groups. These explanations to pupils, we suggest, reflect highly effective teachers' knowledge of their pupils as well as their detailed knowledge of the specific subject objectives or content that they are teaching.

Other links

There was no clear link in our sample of teachers between biographical factors, such as length of experience, or type of training, or experience of in-service training and their effectiveness. These aspects are pursued later in the report in describing how particular teachers have developed, and this information has also been presented through the illustrations in Section 2.

It was perhaps to be expected in the light of the sample size and the findings of previous research that no simple or direct relationships would emerge between the classroom observations and the value-added data (see for example the summary by Dunkin and Biddle (1974) which reports extensively on the sometimes contradictory findings of classroom observations related to pupil outcomes). More recent studies of teacher's behaviours in the classroom and pupil outcomes have found patterns of behaviour which go some way to explaining differences between effective and less effective teachers, but still leave much of the variation between these two groups of teachers unexplained. The discussion in Appendix 2 also summarises some of this literature.

In this project we sought to identify differences between teachers whose pupils were making at least average progress and teachers whose pupils were making much greater than expected progress. Most previous research of this type seeks to distinguish between effective and less effective behaviours. Our interpretation of the results in this section about the differences between a highly effective teacher's behaviours in the classroom and a teacher whose pupils make at least expected progress is that the differences may not be easily observable using the approaches we adopted. The relationship between pupil outcomes and a teacher's behaviours in the classroom is a complex one. Establishing which behaviours account for the differences may either require more subtle and detailed observational techniques or observations which are conducted over a longer period of time (we were not able to assess the extent to which observations of teachers varied over the course of the term or school year, for example). We also suggest a further interpretation based on the knowledge that the literature on effective teaching is only correlational. It identifies behaviours which are linked with outcomes but this does not necessarily indicate that they *produce* those outcomes directly. For example highly effective teachers may tend to have smoother transitions between sections of their lessons, but it may not be this part of the lesson which helps pupils learn directly. The smoother transitions may reflect greater skills in classroom management or better 'craft knowledge' which are observable in the classroom. It may be the cumulative effect of those skills, or the underlying choices and decisions, however, which explains the effect on pupils' attainment.

In terms of the model of teaching and learning set out in Section 1, we have not established any simple relationships between the sections of the model highlighted below. This is consistent with earlier research. It may well be because of the scale of the project (complete sets of observations on four lessons for 32 teachers). In addition, the limitations of observational approaches to observational research which are restricted to comparable categories between classrooms have been noted by other researchers. Doyle (1990) notes the problems of 'fragmentation' which can arise from trying to define teaching behaviours in terms of observable categories (p. 13) and researchers such as Edwards and Westgate (1994) comment on the difficulties of categorising classroom talk.

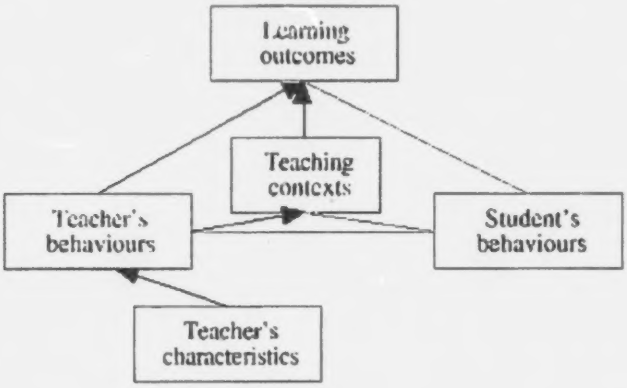

Figure 4.1: Teacher's characteristics, behaviours, teaching contexts and learning outcomes

The limitations of this investigation into the links between the value-added data, the classroom observations and the biographical factors from the questionnaire led the project team to investigate other areas in the model. These areas were particularly in the sections of the model relating to the teachers' knowledge and beliefs which might be related to their effectiveness in achieving higher attainment for their pupils. Furthermore, investigation of these areas seemed likely to support the development work directly in the next stage of the project.

4.4 Summary

- **Some tentative links were found between the observations and the**

value-added data.

- **Some of these links were not consistent either between year groups or for both sets of data. This reflects the inconsistency in the research literature about observable behaviours and the size of the sample of teachers observed.**

- **One area where consistent links were found was in the area of teachers' explanations.**

Section 5: Some relationships between teachers' thinking and their practice

The aims of this section are to:

- **describe the results of the exploration of the development teachers' thinking;**

- **relate these patterns of thinking to classroom practice and to the teachers' engagement with ICT;**

- **interpret the findings in relation to effective pedagogy, teachers' choices and ways of supporting professional development;**

- **relate these findings to the model of teaching and learning underpinning the study.**

5.1 The exploration of thinking about teaching

As part of the initial interview with the 32 teachers in the observation phase of the project, they each undertook an exercise asking them to identify similarities in, and differences between, sets of classroom activities. They discussed these activities in various ways which we believe represented their underlying thinking about these teaching and learning situations (for a fuller account see Appendix 4). Ideas such as 'whole class', 'teacher-led' 'individual' or 'creative' were found to be held in common across the majority of the group of teachers. These ideas were then fed back individually for discussion and validation. Subsequently these ideas were collated and presented again in the form of a 70-item rating scale so they could express a preference for the various ideas where there was a contrast ('teacher-led or pupil initiated learning', 'open or closed activities'). The purpose of this was to understand the teachers' ideas and beliefs about teaching, learning and the educational value of ICT, since these might be affecting their pedagogical choices and the way they viewed and used ICT, as well as their general effectiveness as measured by the progress of their pupils. The preferences were then investigated in order to see if there were consistent patterns or groups of linked ideas and beliefs among the different ways of thinking about teaching and learning. The results of this exercise were again presented to the teachers as part of the final interview so we could ask them to give examples of how they thought their preferences affected their teaching and to check that the information accurately reflected their thinking.

Three main patterns emerged from the group of teachers as a whole. The first pattern consisted of five groups of items. These five groups were:

- pupil empowerment as learners rather than pupils receiving instruction;
- pupil choice rather than teacher direction;
- learning by discussion and pupil enquiry rather than by mechanical instruction;
- preferring complex problems and tasks to simple and straightforward ones;
- a positive rather than a negative attitude towards ICT.

The teacher with whom we worked in the case study 'Developing mental calculation skills with Year 4 pupils through pattern in number using spreadsheets on portable computers' represents this 'pupil empowerment through problem-solving' kind of approach very well. This approach was significantly more common among the less experienced teachers. It was a positive predictor of value-added in reading at Key Stage 1, but a statistically significant negative predictor of value-added in mathematics at Key Stage 2.

The second pattern consisted of four groups of items. It was clearly linked with a core subject preference. It was made up of the following groups:

- high importance given to teaching English rather than mathematics;
- group-work rather than class-teaching, emphasising literacy rather than numeracy;
- a preference for working with others rather than individual study;
- presenting work that is new and interesting rather than routine and repetitive.

The teacher in the case study entitled 'Developing calculation skills with Y2 pupils using ICT' is one for whom these ideas were important. This pattern was not related to length of teaching experience or to value-added in either reading or mathematics.

The third pattern consisted of three groups. These were:

- using a formal and specific rather than an informal and general approach;
- a structured rather than a less structured approach to teaching and learning;
- active learning of subjects rather than a less active topic-based approach.

While these sets of ideas were important for some of the development teachers, none of the illustrations fully exemplifies this pattern. More experienced teachers were likely to favour more the more formal, subject-based approach, but there was no statistically significant link with value-added. (For further details of these patterns and the 12 scales or dimensions of which they are composed, see Appendix 4.)

The next step was to look for links between the teachers' thinking and the questionnaire data, as well as for links with the classroom observations, especially when ICT was involved. Significant links were found between the twelve dimensions of thinking and the questionnaire and observational data. There was also a small number of interesting links with the value-added data.

The main reason for this investigation was that the team wished to take account of how teachers' underlying beliefs influenced their pedagogy, their use of ICT and the ways in which they interpret, adopt and adapt attempts to modify their classroom practice (from the extensive literature on teacher development, see Appendix 3, for further details). In terms of the model of teaching and learning underpinning this research we thought that there would be identifiable patterns linking a teacher's approach to teaching and their observable behaviours in the classroom. It also seemed likely that different forms of intervention or different kinds of support might be more effective with some teachers than others. We hoped that the information would provide insights into the development approaches and would offer some quantitative validation against which we could check our experiences.

The number of teachers involved in this aspect of the study is small (19) and we make no claims about broader implications for primary teachers generally. However the links we found in this project were valuable to the project team and raised interesting questions about teachers thinking and development more broadly; we suggest that the method is worth investigating with a larger sample to see if the patterns and relationships are repeated.

5.2 Links between teachers' thinking, their classroom practice and their engagement with ICT

The full analysis reported in Appendix 4 came after the planning stages of the interventions. However, the information about teachers' constructs helped to shape the second phase of the development work and, with hindsight, it is possible to identify how the project team negotiated development aims and approaches that took into account the teachers' thinking about effective practice. For example one very experienced teacher clearly exemplified aspects of the teacher direction dimension, while he also favoured whole class interaction and learning by discussion and pupil enquiry. The intervention agreed explored the use of question generation activities which were introduced with an overhead projector. Later the activities were undertaken using an interactive whiteboard, and followed up as whole class activities on a cluster of computers, but aimed to develop pupils' comprehension with speech support to ensure all pupils were able to read more challenging texts. Here the teaching strategies and the technology both fitted in well with the teacher's expressed views and orientation (see above Section 2, 'Using short rhymes and other texts to enhance reading comprehension').

In another case a relatively new teacher had a very positive attitude to ICT and sought to promote pupil empowerment as learners. The intervention negotiated with this teacher was to use spreadsheets with a set of portable computers to investigate pattern and relationships in mathematics. The teacher strongly believed that pupils needed to develop their IT capability in ICT tasks and this influenced his pedagogical decisions. (See Section 2, 'Developing mental calculation skills through pattern in number in Year 4'.)

There were also occasions when negotiations were less successful. The project suggested to one teacher that a paired-learning approach with ICT might be effective, in which pupils selected spellings, might be effective. The activities were piloted, but continued in a less individualised form without using ICT, perhaps reflecting the teacher's stronger preference for whole class teaching and her lack of confidence with ICT.

How teachers' thinking is related to their use of ICT

There were four dimensions of thinking that were significantly linked with attitudes towards using ICT. The information about ICT from the questionnaires and from our observations sheds further light on this key area and the relevant significant links between thinking and practice are summarised below:

A positive rather than a negative attitude towards ICT

> Pro-ICT teachers were unsurprisingly generally keen on the use of ICT in education and reported that ICT made them feel good about their teaching. Four of them were ICT co-ordinators and as a group there is strong evidence that they gave priority to teaching children ICT skills with targeted assessment objectives. The teachers themselves had substantially higher levels of computer skills and were rather more likely than those with a negative attitude to have a computer at home which they used for school work. They provided more opportunities for class computer usage and were more likely to use computers for database work and in large projects, believing that pupils had adequate keyboard skills for using computers. They thought that parents were positive about computers and said that it was not hard to include computer work in the curriculum. They were also positive about the educational potential of the Internet.

Teacher direction rather than pupil choice

> Teachers who emphasised teacher direction rather than pupil choice tended to have a lower level of self-rated ICT competence and gave much lower estimates of computer time per pupil per week. Although they were quite likely to provide access to computers during playtimes, they reported relatively little use of more demanding computer activities with spreadsheets and databases. Highly directive teachers felt that access to more appropriate subject software would not increase their use of ICT. When they did provide ICT activities, their pupils often engaged in social chat with helpers and in mathematics lessons were more likely to talk with peers about functional than about academic aspects of the task. While ICT did not feature strongly in either the thinking or the practice of the more directive teachers, they were more likely than others to make use of regular help from other adults in their classrooms.

Pupil empowerment as learners rather than pupils receiving instruction

> Both the quantity and quality of pupil's ICT experience tended to be high with the teachers who took the pupil empowerment stance. With these teachers pupils often sought teacher help with functional problems when using ICT to support numeracy. Teachers favouring pupil empowerment placed high value on subject-specific software and felt that there was a shortage of this. They were also inclined to feel that it is more time-consuming to prepare lessons that include ICT activities.

A preference for individual study rather than pupils working with other pupils

> Teachers who liked to have pupils working on their own reported low levels of computer usage, especially for number work and basic skills. However they acknowledged that pupils could cope with the complexities of computer software and several allowed pupils to use computers during playtimes. Pupils were reported to work on their own when they did use computers in the classroom. Relatively high levels of off-task behaviour were seen when ICT was incorporated into English lessons.

Some implications

One very clear finding is that particular groups of teachers are much more receptive to ICT than others. Teachers who are enthusiastic about ICT are likely to favour pupil empowerment as learners and probably like children to work collaboratively. However, it is the teachers with the best-developed ICT skills who are the greatest enthusiasts. Those with negative attitudes about ICT are likely to be more directive in style or may prefer children to work individually without ICT. These differences in thinking, skill and attitude clearly have implications for development and training for teachers in using ICT across the curriculum.

With teachers who are ICT enthusiasts there is little need for development work to be constrained by technical and operational factors. Teachers and pupils may respond well to extending their use of ICT for demonstration purposes, for collaborative project work, research and communication. They will be keen to find new ways of using ICT across the curriculum in ways that involve challenging work, creative thinking and decision making. One example of this is the illustration entitled 'Developing the correct use of omissive apostrophes with pupils in Year 4 using multimedia'). Teachers and pupils with a strong ICT skill base will also be ready to exploit the capacity and range of ICT through the use of an intranet and/or the Internet.

Less adventurous and more controlling teachers with reservations about the educational value of ICT will probably need to improve their ICT skills and to acquire the positive attitude that usually goes with such skills if they are to use ICT more effectively. They may also have to be persuaded that ICT-supported activities can help pupils acquire subject knowledge. For example, they may see value in the kind of software that provides practice with tables or with learning spellings. Some may be attracted by the direct instruction offered by an integrated learning system, while others may prefer to use a generic tool such as Textease which can be used for word processing but has wider possibilities which can be gradually explored. If directive teachers are encouraged to produce their own teaching materials or to use or adapt them from the web, they may come to appreciate ICT as a useful instructional tool. However, there is perhaps a danger that some directive teachers may develop an over-controlling approach so far as ICT is concerned, structuring work to such an extent that pupils no longer have to think for themselves.

At the other end of the continuum, a strong preference for pupil empowerment and complex problem-solving was a significant negative predictor of mathematics value-added at Key Stage 2. This strongly suggests that a balance is beneficial, with teachers providing both closed and open tasks according to the demands of the particular content and skills being taught. Teachers who value pupil empowerment as learners are likely to view drill and practice software unfavourably, unless features which allow a high level of pupil choice are built in. Subject-specific software is likely to appeal to such teachers, for example talking books where children have a choice of level or strategy. More demanding uses of ICT linked with pupil investigation, data analysis and problem-solving are likely to be used effectively, and pupils may be able to handle ambitious multimedia projects, such as the production of a class newspaper or the creation of an instructional package.

A majority of the project teachers expressed a preference for having children work individually rather than interacting socially or collaboratively (clearly expressed by 12 out of the 19 teachers). Individual work is a long-established norm, especially in mathematics lessons. However, two or more children often have to work on a single computer so everyone will get a turn, and this makes it more likely that children will interact when using ICT. Low levels of computer use for number work and for the practice of basic skills were reported by those teachers who preferred individual work and by those who preferred teaching mathematics to teaching English. In order to help these teachers see the potential of ICT to contribute to the development of literacy and numeracy it may be sensible to ensure that a range of ICT resources is available for individual access as and when required. Such resources could include spell-checkers, calculators, electronic dictionaries and thesauruses and facilities such as CD roms and the Internet as reference tools. When interesting information is found by individuals, teachers may wish to encourage pupils to share it more widely, for example in a plenary session or by 'publication' for an outside audience. Teachers who believe that individual study makes an important contribution to the development of literacy and numeracy may favour applications which record individual performance. Alternatively encouraging use of the computer for demonstration may be helpful to these teachers, as those who indicated relatively stronger preference for mathematics also tended to favour whole class teaching.

Inferences of this kind are interpretative, and with such a small sample as this must be seen as tentative. However we certainly found coherent patterns of thinking and behaviour in our sample of development teachers which made increasing sense to the project team as the work progressed. While there were some ICT enthusiasts, these were in a minority. Further implications for effective development will be examined in the following section.

5.3 Effective pedagogy, teachers' choices and their professional development in using ICT

Are we now in a position to make any generalisations about effective pedagogy, either in general terms or more specifically in relation to the use of ICT to support learning and instruction?

When the 12 patterns of thinking were considered separately, none was found to be significantly correlated with the PIPS value-added scores relating to the same period (1997-8). However, the unique contribution of each pattern was subsequently determined by holding constant all other patterns in turn by means of partial correlation technique. This showed that a statistically significant contribution to both mathematics and reading value-added came from *'presenting work that is new and interesting rather than routine and repetitive'. Teachers who do this are likely to have high expectations of pupils and they like to present work that is not only interesting but cognitively challenging. We interpret this aspect of teachers' thinking as part of a more general motivational factor that can be described as enthusiastic and challenging teaching. Only one other pattern of thinking, a preference for 'individual study rather than working with others', was helpful in predicting mathematics value-added and was second in importance in predicting reading value-added* *(but not quite significant).*

Different combinations of the 12 dimensions of thinking were little more effective than a single dimension in enabling us to predict value-added results. However, one further result was of interest. As reported in Section 4, the use by teachers of examples and counter-examples was found to predict value-added in both mathematics and reading. The level of this prediction was increased (and remained significant) when the teachers' degree of preference for 'active learning of subjects rather than a less active topic-based approach' was added in.

We must, however, be cautious in interpreting such results. It is clearly not possible to argue from the data in this study that pupils' literacy and numeracy attainment will be improved by encouraging effective and highly effective teachers like those involved in the development phase to adopt a particular set of beliefs. We suggest that are at least two reasons for this:

- *different approaches are likely to be more or less effective in different subject areas and with different age-groups; and*
- *different teachers can achieve successful outcomes with very different approaches.*

Most teachers operate with a complex set of beliefs and skills which interact dynamically. It is therefore unlikely that a snapshot of 19 teachers' thinking and observed practice will enable us to make valid generalisations about effective pedagogy. However, we can provisionally name certain factors that were not significantly associated with value-added outcomes across our group of teachers. This lack of association across a group does not, however, imply that a particular approach does not make a contribution at level the level of an individual teacher.

Partial correlation technique identified two dimensions of these teachers' pedagogical thinking that did not clearly link with value-added gains in reading. These were:

- *teacher direction rather than pupil choice;*
- *group-work rather than class-teaching, emphasising literacy rather than numeracy.*

It is also of interest that one dimension did not have a clear association so far as mathematics value-added was concerned. It was:

- *class teaching rather than group work, and emphasising numeracy rather than literacy.*

This suggests to us that effectiveness in teaching for our group of teachers lay in deciding *when* particular strategies and approaches are effective, rather than in the approaches themselves.

In our sample of teachers there were some consistent relationships between their beliefs about effective teaching and their practice. However, teachers are individuals with different sets of values, ideas, personal styles and pedagogical repertoires. While many pedagogical practices for which there is research backing were seen in our observations, they tended to be clustered in different groupings of teachers according to their thinking rather than being more often used by the teachers with the highest value-added results.

We found no evidence that teachers who reported greater use of ICT and believed it to be important were more effective in value-added terms. However, we did find from our 1997 questionnaire that teachers who agreed with the statement *'Computers make me feel good about my teaching'* were more likely to be in our high rather than average value-added group. But was this enthusiasm anything other than a sign of a more general enthusiasm for the kind of teaching that holds the interest of pupils? It was also the case that those who agreed with this particular statement were also those who used a computer more often for class demonstration: so they may therefore have had this in mind rather than pupils using computers for basic skills or number work.

So far as different kinds of computer use are concerned, we found significant links between mathematics value-added and the reported use of computers for class demonstration and in 1997 for the study of patterns and connections through spreadsheets and databases. Both these types of use make demands on the ICT skills of the teacher and were associated with positive feelings about teaching as well as with self-rated ICT competence. But again we have to ask whether there was an ICT-specific effect here or just a more general factor at work indicating that these teachers were prepared to develop their professional skills in areas where they felt they were able to make a difference to pupils' learning .

The latter interpretation seems more plausible and is supported by the analysis that we carried out on the 12 dimensions of teachers' thinking, which found a correlational link between *'presenting work that is new and interesting rather than routine and repetitive' and value-added. It seems clear that if computers and other forms of ICT are to become powerful educational tools, they will have to be managed by effective, enthusiastic and challenging teachers. ICT can indeed be effective, when used purposefully.*

One conclusion is certain: that the clearest and most prominent dimension in the teachers' thinking (which is about the extent of teacher direction rather than pupil choice and empowerment) was not clearly linked, either positively or negatively, with pupils' progress. At the same time, this 'teacher direction/pupil empowerment' dimension was strongly associated with attitudes towards ICT, with the more directive teachers having more negative attitudes and providing significantly less pupil access to computers.

It is also clear that in the schools that we studied ICT was not making a significant contribution to the development of literacy and numeracy in the period immediately prior to our intervention work. Our task was to attempt to change this, taking account of contextual factors such as the thinking and practice of individual teachers, their attitudes, skill levels and confidence concerning ICT and their access to hardware, software and support. Our study of the teachers' thinking and practice indicated that we should encourage:

- enthusiastic and challenging teaching with ICT as an explicit pedagogical strategy (instead of computer activities being considered as secondary or additional);
- focused subject-related purposes for using ICT, with an

emphasis on active rather than passive learning;

- opportunities for illustration and demonstration of procedures, concepts and new learning with ICT, for example through the presentation and discussion of work in whole class teaching and particularly in plenary sessions;
- rather more focused individual work with ICT, unless this was organisationally or pedagogically inappropriate.

Our general conclusion is that it is important in both English and mathematics lessons to strike a balance between organisational and pedagogical options such as whole class and group activities; between talking to children and listening to children; and between learning new knowledge and applying knowledge. The basic structure of the National Literacy and Numeracy Framework lessons facilitates this. A pedagogy in which strategy is matched to purpose is what is desirable. Our work suggests that there are probably more similarities than differences between the effective teaching of mathematics and English. ICT is an exciting tool, but so far not many teachers have been able to use it effectively to help raise standards of literacy and numeracy. Understanding the specific patterns of belief and thinking as well as the skills and knowledge of teachers has an important part to play in supporting effective development in these areas.

To return to the model of teaching and learning relevant to this section of the report, we believe that we have found patterns which link particular aspects of the diagram (figure 5.1). Specifically, this is in *teachers' approach to teaching*, some aspects of their *characteristics* (such as number of years in teaching) and their observable *behaviours* in the classroom.

Although there are some direct overall links between these three areas and *the learning outcomes* (the relative attainment of pupils in this study as measured by PIPS) or between teachers' *behaviour* and *outcomes* (as indicated in Section 4) there are stronger patterns of association between all four of these sections of the diagram which help to explain the overall relationships.

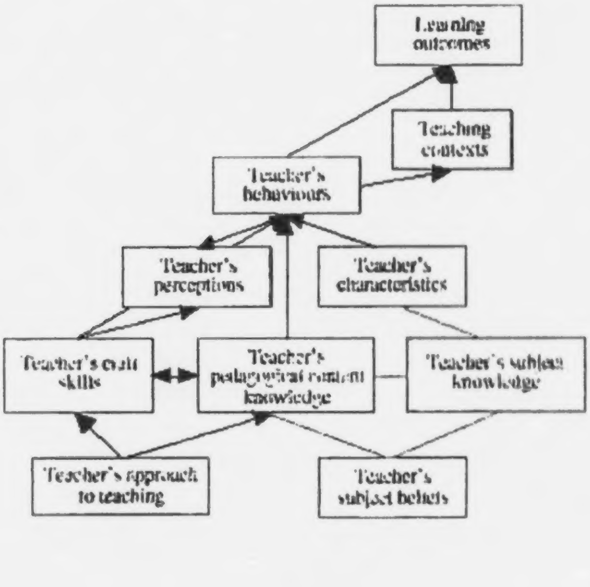
Learning outcomes
Teaching contexts
Teacher's behaviours
Teacher's perceptions
Teacher's characteristics
Teacher's craft skills
Teacher's pedagogical content knowledge
Teacher's subject knowledge
Teacher's approach to teaching
Teacher's subject beliefs

Figure 5.1 Teachers and learning outcomes

In the next section we look at the approach to development and the 'scientific' underpinnings of this particular 'art' form. The relationships between beliefs, teaching behaviours and pupils' outcomes discussed in the report so far indicate that supporting teachers' choices in effective pedagogy using ICT in literacy and numeracy must take account of a range of factors if it is to have an impact on pupils' attainment.

5.4 Summary

- **The project team undertook a series of activities designed to explore teachers' thinking and choices about teaching and learning in primary classrooms.**
- **The aim of this was to provide information about the teachers and their teaching which would help to support the analysis and conduct of the development work.**
- **Significant patterns emerged in these ways of thinking which were internally consistent.**
- **Further significant patterns emerged when these ways of thinking were related to data from the observations, the questionnaire and the relative performance data about pupils.**
- **Teachers who favour ICT are likely to have well-developed ICT skills and to see ICT as an important tool for learning and instruction. They are also likely to value collaborative working, enquiry and decision-making by pupils. Teachers who have reservations about using ICT are likely to exercise a high degree of direction and to prefer pupils to work individually.**
- **No single dimension of teachers' thinking emerged as a clear indicator of value-added pupil learning gains.**
- **A combination of preferring subject-based to topic-based teaching and active to passive learning linked with the frequent use by the teacher of examples and counter-examples proved to be a reliable indicator of effective pedagogy in both literacy and numeracy.**
- **Professional development initiatives to promote the effective use of ICT need to take account of the diversity of teachers' thinking and existing practice if they are to find appropriate 'hotspots'.**
- **A general factor of effectiveness may link enthusiastic and challenging teaching with teachers taking up new ideas and requiring new skills (such as those required for the effective use of ICT).**

Section 6: Supporting the Development of Effective Practice

The aims of this section are to:

- **provide information about the rationale for the approach to development which the project team adopted;**
- **explain how the data for the illustrations of effective practice were collected;**
- **to report on the work of the project team in supporting effective development in ICT;**
- **identify implications for the development of effective pedagogy in literacy and numeracy using ICT.**

6.1 Effective practice and effective development

The main issues in accurately describing any process of change in teaching are in describing the complex interplay between different factors in any particular teacher's development. These are made more complex in this project by the relationship with ICT, which itself demands both personal and pedagogical technical skills and competence. The research literature on effective learning for primary pupils and on teacher development already contains significant information relevant to improving the effectiveness of teaching. ICT is relatively new and although there is considerable published information about it in relation to teaching and learning, there is comparatively little which contains all of the key elements of this project which aimed to support teachers in making effective choices about when, when not and how to use ICT in order to support improvement in pupils' attainment in literacy and numeracy in primary classrooms. This section describes some of the background factors which the project team incorporated into the planning and implementation of the development work. We also hope that the presentation of our approach to development will be helpful to others planning to use ICT to raise pupils' attainment in primary schools. (A fuller review of the literature on ICT, pedagogy and attainment is presented in Appendix 2 and on effective pedagogy more broadly in Appendix 3.)

6.2 The approach to development

The broad findings of school effectiveness research influenced the underpinning factors which the project team considered would 'travel well' (Gray, Reynolds *et al.* 1996) and which could therefore be applied to other teaching situations. In particular this research base influenced the design of the observational instruments with categories such as off-task, praise, length of lesson segments as well as more qualitative judgements about transitions and teachers' wait-time. Appendix 3 summarises some of the relevant literature on effective teaching which influenced the team.)

There is also a considerable body of research both about aspects of pedagogy and about pedagogical content knowledge (see for example, Berliner and Calfee's (1996) comprehensive academic review or Ysseldike and Christenson's (1996) teacher-friendly summaries of research on instructional effectiveness) as well as meta-analyses indicating relative effectiveness of different interventions (e.g. Hattie, 1987). This range of sources of information formed the background for the work of the research team as well as more detailed subject-specific research in literacy and numeracy. The research team was able to draw upon this both in the planning and implementation phases of the project, as well as in the negotiations and discussions with the teachers about the specific development projects in particular classrooms. Using their knowledge of research and development in primary classrooms, the team discussed possible ideas for development projects with each of the teachers and agreed initial aims and starting points. Some of this information was specifically related to the subject area the teacher had chosen and some to more general aspects of pedagogy (e.g. paired collaborative work) depending upon the different teachers' preferred strategies and approaches.

All of these strands (content, pedagogy, pedagogical content knowledge and the challenge of bringing about change and development effectively) formed the background to the specific development projects undertaken with individual teachers in this project. Overall, however, the common characteristic of the regular contact with our development project teachers was a pragmatic problem-solving approach. In working with teachers we asked them to identify aspects of their teaching where they would like to have a greater impact on pupils' attainment. We provided contextualised information about their practice from our observations and other relevant data. We jointly identified possible courses of action and solutions both from experience and from research evidence. Evidence was collected to determine what impact the development work had on pupil outcomes, and all of this information was fed back to the teachers through regular consultations and discussions. Support was provided both for technical problems which arose with equipment and in working with pupils to introduce new software or equipment where this was necessary.

It is clearly also necessary to regard findings from school effectiveness about generalisable or 'global' teaching behaviours with caution. They are correlational findings which means that although there may be clear links or associations, there are not necessarily causal links. In other words if a teacher performs the behaviours associated with effective teaching, then these behaviours (such as amount of praise given in a lesson, or the amount of whole class teaching) might not necessarily make them effective in improving pupils' performance. These global behaviours are only the tip of the iceberg. Two teachers apparently behaving in the same way may be interpreting pupils' responses and then planning future learning activities very differently because of their different beliefs about the subject, or their approaches to teaching. In terms of the model of teaching and learning underpinning this report, we are suggesting that school effectiveness research provides invaluable information about the top section of the diagram, or what tends to happen in more effective classrooms, but that the team believed that effective development work in this project should try to take into account further areas of the model when supporting effective change.

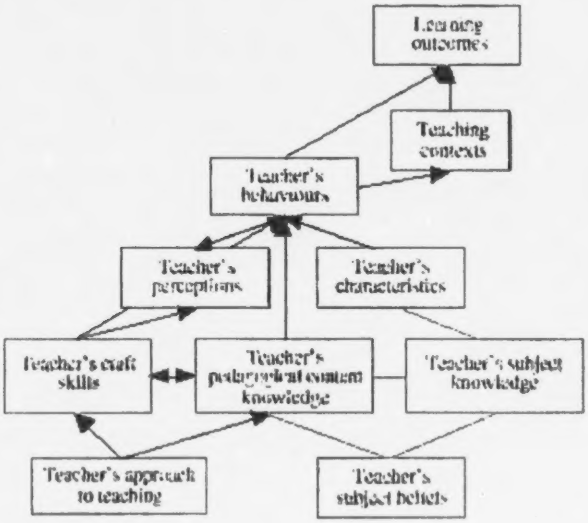
Learning outcomes
Teaching contexts
Teacher's behaviours
Teacher's perceptions
Teacher's characteristics
Teacher's craft skills
Teacher's pedagogical content knowledge
Teacher's subject knowledge
Teacher's approach to teaching
Teacher's subject beliefs

Figure 6.1 The model of teaching and learning

This caution about the limitations of research findings in this area can be found in those working in the areas of monitoring and school effectiveness (e.g. Coe and Fitzgibbon, 1998) and school improvement (e.g. Stoll's reservations (1995) as well as those working in teacher development more broadly (e.g. Elliott, 1996). All of this research, and in particular the findings of the Effective Teachers of Literacy and Numeracy (cited above) as well as Rich's (1993) cautionary tale of teacher development (where some expert teachers struggled to regain their expertise with a new pedagogical approach) suggested to the team that there may be something about teachers' underlying beliefs and knowledge that needs to be taken into account more fully if development work seeks to have more than a superficial impact upon teachers.

The understanding of teacher development which underpins this approach is that development is more likely be effective if teachers are actively involved in the process of critically reflecting on and analysing evidence about their own practice. In addition, any new approach or innovation, particularly with ICT, needs to be tried and tested in the classroom by the teachers themselves before it can become an accepted part of their repertoire of strategies or approaches (Somekh and Davis, 1997). This is based on the belief that teachers need practical experiences to change their practice and that their theories or beliefs which govern their practice grow from a mixture of experience, analysis and exposure to external expertise. There is clearly a tension here between development with specific objectives in view and having the teacher in control of the development. Our project tried to strike a balance between having specific objectives (both in terms of pupils' attainment and effective pedagogy) and between seeing the teachers as the 'locus of control' in developing their teaching effectiveness (Higgins and Leat, 1997). We must also acknowledge that we had very little control over some of the school factors influencing successful development, such as the commitment of the head teacher and the 'culture' of change (Fullan, 1991).

Feedback to teachers

As part of the development work the teachers received feedback about aspects of their classroom behaviours (e.g. amount of praise, off-task scans) which had been observed. This information was presented graphically using box plots with an indication of their own classroom observations marked on the chart. The information was presented so that they only knew their own results relative to the rest of the group. The implications of these results were discussed with groups of the teachers, together with information about effective teaching behaviours from the research literature.

Information from the investigation into their thinking was also fed back at different stages of the project. Initially this was to validate the information, it also provided a useful focus for discussion about their choices and priorities in the classroom.

An additional aspect of the development work in the autumn term of 1998 was that some of the teachers in the project became involved in informing other teachers in their own schools about what they had done and therefore in supporting their colleagues to develop work in their own classrooms. We believed that this would help the original teachers to analyse and express more clearly the process of development which they had themselves experienced. In January 1999, at the end of the development phase of the project, eight of these teachers presented the work they had undertaken alongside members of the project team at a conference in the North East of England. This conference informed local teachers of the development and choices that they had made over the course of the project as well as providing a valuable opportunity for discussion and review of the work undertaken. The teachers involved in the development work were therefore given the opportunity to discuss and interpret the findings from both the qualitative and quantitative data in the project. In addition the team had the opportunity to test out some of the preliminary findings from the development work.

Summary of development approach

The significant aspects of the project's development approach can be characterised as follows:

- each teacher identified the general area of focus (literacy or numeracy) according to school and personal need;
- the precise area of development was negotiated (e.g. counting skills or improving punctuation and use of connectives in writing) and possible solutions discussed by specific team members and teachers;
- the pupils' baseline test and re-test results were shared with their teachers to provide diagnostic feedback about their own pupils;
- quantitative information on 'global' teaching behaviours (e.g. amount of praise used in lessons) by individuals (relative to the average of the other teachers observed in the project) was provided as a focus for private discussion;
- information on each teacher's ideas about teaching and learning was fed back to them individually;
- there was intensive support in first term (Summer 1998). This intensive

support included:

- support with planning, particularly in identifying subject-specific learning outcomes for pupils;
- support with developing teacher's ICT skills (both at the planning stage and in school);
- support to develop pupils' ICT skills (e.g. through use of University computers) to enable subject-specific objectives to be tackled;
- support with technical problems as they arose;
- the teachers were encouraged to share development ideas and work with each other and with other teachers in their school;
- regular contact (weekly or fortnightly visits to local schools and weekly telephone contact with development teachers in other parts of the country);
- time for discussion and reflection with project staff.

This approach was repeated with a similar focus in the second term plus:

- there were opportunities to inform and work with colleagues in their own schools;
- information about preferences in beliefs about teaching and learning were returned and discussed individually;
- a final conference to review development projects was held with development teachers presenting their work alongside the project team.

Of the 32 teachers who completed the observation phase, 20 continued with the project into the development work. Comparisons across development projects were made to investigate any patterns which emerged between the case studies so that any wider or more general implications could be analysed.

6.3 The particular challenge of effective development work in ICT

Development work in ICT also needs to address a further issue: teachers' skills and confidence in using ICT. Accordingly the team had built in to the research design opportunities to make this issue more explicit. In the analysis of the first questionnaire for the project in autumn 1997 the project team identified a number of potential challenges to any development work which tried to encourage the use of ICT in classrooms (reported in Section 3 above).

Providing effective support

A summary of all these challenges, together with any difficulties identified from the interviews and research literature, was then presented to the project teachers in the development phase in a further questionnaire. In particular, the teachers were asked to describe the kinds of things they thought were preventing them using ICT effectively in their teaching.

The results of their answers are displayed in the chart below (Figure 6.4). The scale used was from "1 - No problem" to "5 - A real barrier". The higher up the list, the greater the barrier (n = 18).

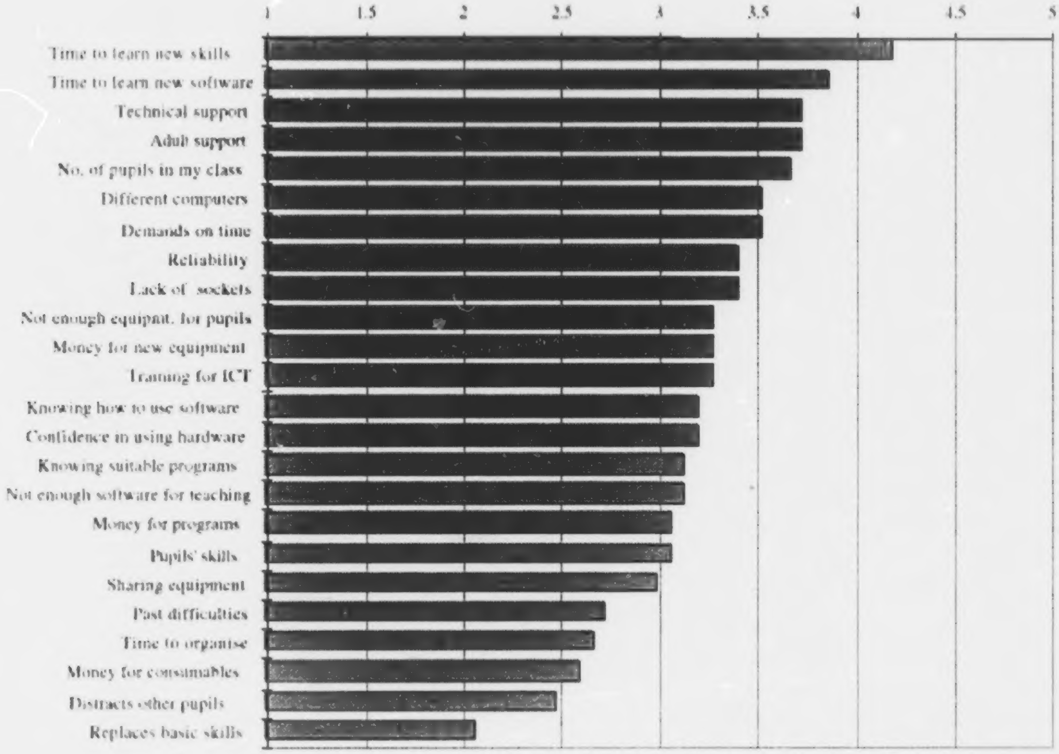

Figure 6.2: Chart of perceived barriers

Part of this set of issues was elicited through a questionnaire and so it should be noted that they have been prompted to a certain degree. However, the challenges were identified from information from the project's initial questionnaire (which had 250 responses) as well as information from the interviews with the 32 observation phase teachers.

As can be seen, **time** is consistently the biggest challenge reported by the teachers:

- *time for them to learn new skills* themselves (the greatest difficulty identified by the teachers). Indications from the analysis of the first interviews suggest that these are generic skills such as learning how to use a new computer's desktop organisation, filing routines and shortcuts like setting up template files, although these were not mentioned specifically here;

- time for them *to become familiar with new software* or *to learn new programs*. This is clearly something that they felt very much and was related to another of their concerns about being able to decide about whether to use a particular piece of software or not (see below);
- time to assimilate new software so that they then feel in a position to make professional judgements about *knowing which software* might be appropriate to use in a given situation.

The next set of difficulties they identify appear to be related to **equipment**. The need for *technical support, money for new equipment, reliability of equipment, not enough equipment, not enough electrical sockets*. These problems were not as important to the teachers as those related to time mentioned above.

A further clear distinction can be made between issues relating to **pupils** (the number of pupils in my class, lack of equipment, adult support) and the number of machines available for the pupils to use.

There are also strands in these specific challenges to using ICT which are more general and apply to the broader demands of the classroom and pressures on teaching more generally. This reflects a concern about the priority of teaching effectively with ICT amidst the other demands of the curriculum. The teachers in the project talked about this in relation to ICT. They felt they were now expected to spend a relatively greater amount of time teaching the whole class or teaching a group intensively. They reported that there was therefore less time for groups or individuals to use ICT in lessons with a greater whole class emphasis and that was difficult to organise and manage a completely independent group using ICT. This was in part what they had indicated in their desire for more *adult support* in their classrooms to ameliorate this problem and in identifying the *number of pupils in my class* as a challenge. Both of these are also related to the pressures they felt about the time available for each pupil, either because of the amount of equipment, or the support that they thought that pupils needed to learn the IT skills which would enable them to succeed with the subject-specific objectives that they had identified for literacy or numeracy sessions.

The one pedagogic issue identified by the teachers was knowing which software was appropriate. However, in general, the pedagogical issues which teachers identified were relatively less important than the other challenges discussed above. By comparison with these other issues, they were less concerned by the suggested possibility that ICT might *replace basic skills* and they were only slightly more concerned by the time factors involved in *organising their classrooms* or the possibilities of the ICT *distracting other pupils*. Surprisingly perhaps, they were not too concerned by *difficulties they had met in the past*, as for one or two teachers this had been extremely important. For these teachers it was important to ensure that technical support was provided promptly (particularly to overcome problems with printers).

Relative importance

Asked to highlight the three most important issues, every one of the project teachers chose *time* in some form although they did split fairly evenly on whether this was teacher related time (52%: time to learn new software, new skills, etc.) or pupil related time (48% time per pupil per computer, time to teach them new skills, etc.).

More than half the group chose *support* as one of their three important issues. Again, this split into two sub-sections: the need for technical support within school (40%) or the need for adult support for working with the pupils (47%). Just over a third of the group said that they felt that they needed more ICT training in using equipment and software.

The next most important issue was a collection of more mundane issues. These were mentioned by just under a half of the group and are probably a reflection of some of the specific the budget issues in particular schools. These include *money* (for software, consumables, and for new and replacement equipment, etc.), the *lack of electrical sockets* in the right places and the *lack of equipment* generally.

Analysis of the first set of 30 interviews from before the development phase had found a similar range of problems. The quotations below exemplify the issues mentioned.

Time to learn about new equipment:

> "We're changing to PCs and I've got to learn how to use them too. I just don't know when you're supposed to fit it all in."

Time to learn about new software:

> "I was given a new CD ROM but I've been letting the children explore it at play times, I just haven't the time to see what it is capable of."

Amount of equipment and time for pupils to use it:

> "So, it's the amount of time allocated, the number of computers you've got in the room, and the time you've got to actually teach the pupils how to use the computer or teach the lessons, isn't it, it's the resources."

Reliability of equipment:

> "Reliability of technology will have to improve. You cannot have a classroom set up specifically for using computers and it not work."

> "Well, I think one of the big fears that teachers have is that you get everything set up and then it all crashes, you know? ... I think that's really at the back of teachers' feelings about the computer because they don't know whether it will be reliable."

Money for new equipment:

> "And there's the money that you spend. Because if you think how many books you could buy for £1,000, when you buy one computer system, is it really that much better?"

> "It's the cost factor. I mean, if I had five in my room, I would use five in my room... it's just the money holding things back, but I think in ten years time there will be computers in every classroom and there'll be five to ten in every room."

Teachers' skills and confidence:

> "Because many teachers don't have this understanding, they find it difficult to use programs that they don't know. So they stick to programs that they do know, which are either outdated or inappropriate."
>
> "But again, unless the teacher has a good base, a good ICT skills and knowledge base, they won't see the benefits and they won't be able to try different activities, because they feel that they can't do it themselves."

Or even a combination of these: pupils' skills, reliability of equipment, adult support and teachers' time in the classroom!

> "But if a child just knocks one button, they mess it up, and they cannot put it right. It needs me or another adult to put it right, and if I'm trying to do too many other things in the classroom, I will say, well, let's just switch it off and I'll set it up again later. It doesn't always happen like that, but it is difficult when they're so young, and sorry to say it, but computers frequently go wrong."

Focus group discussion with some of the development teachers

As part of the development work a group of the project teachers were invited to discuss the issues involved in incorporating ICT effectively. Several significant issues were raised, most of which reflect the findings summarised above. A few others were raised which are either new or significantly affect the interpretation of the importance of the issues that had previously been described.

- It is difficult for teachers to devote time to children who are working on computers where this is only two or three pupils at a time; especially in R and Y1 classes.
- The number of computers per classroom was low (usually one, occasionally two) and raises some problematic issues.
    - There is a need for big screens for demonstration so that all pupils can see the screen at the same time when the teacher wishes to use the computer for direct teaching. This was specifically discussed in relation to teachers using ICT effectively in literacy and numeracy lessons.
    - Organising how pupils have their 'turns' causes some teachers difficulty.
    - It is difficult to increase the time each pupil gets at the computer. This has been made more challenging as the amount of time spent in whole class teaching in literacy and numeracy lessons has increased.
    - It is difficult to ensure every pupil is taught (and actually learns) the necessary ICT skills which they need to achieve curriculum objectives. In

    particular some teachers reported that assessing when pupils had sufficient ICT skills to achieve specific curriculum objectives is difficult. It is easy to assume they have the skills needed, then discover that a lack of a particular skill stops them achieving what was intended. One example given was word-wrap in word processing. If pupils routinely enter text, but do not have to edit it, then checking that they have used the return key properly is easy to miss. However if you then try to redraft the text the extra spaces and missing returns distract pupils from the redrafting objectives.

  - (Some schools now have clusters or rooms with suites of computers to address these last two issues by teaching specific ICT skills to groups or whole classes. The project also tackled this by teaching pupils on a University cluster or on an LEA's ICT suite how to use a program so that the teacher could focus on literacy or numeracy objectives back in the classroom.)
  - Pupils are motivated by ICT work but this enthusiasm can lead to frustration - particularly for younger pupils - when they have to wait a long time to start an ICT activity. The survey of pupils' views (Appendix 1) adds to this picture in particular about sharing computers which can also be frustrating from their point of view.

- The time needed for teachers to learn new software has increased with the complexity and sophistication of the software. It is no longer possible to learn how to use new software quickly. Some teachers felt that it had taken them a long time to learn how to use basic software for word processing or data handling well.
- Technical support
  - As new equipment or operating systems are introduced basic start-up issues are growing. This suggests a need for more practical support in each school to facilitate the changes (e.g. the time and knowledge needed to set up templates on each computer with appropriate font and point size to make using a writing program easier for pupils to get started).
  - Expectations of what computers can do have increased. However the technical problems have

also increased along with the complexity and sophistication of both machines and software. When things go wrong (as they inevitably do), the need for immediate, or at least rapid, technical support in school is crucial. Teacher also felt there was the growing pressure upon time in the curriculum as many of them were coming to terms with the literacy hour, and planning for numeracy lessons.

  - The cost of buying-in technical support is high, particularly for primary schools. This has meant that some schools have chosen a lower level of service agreement than they needed. This in turn leads to more problems which then become part of a vicious circle.

- Past frustrations, especially with printers, can lead to de-motivation. This can be particularly significant at an individual level.

- The ever growing cost of consumables is getting to be a very significant problem in some schools which are already pressed financially. Colour ink jet cartridges typically cost about £25 and yet one teacher reported that the budget for ICT (software and consumables) for the whole school was only £150 a year.

Repeat of questionnaire items

The teachers involved in the development phase of the project were sent a second detailed questionnaire in December 1998. This questionnaire was also sent to a random sample of those who had completed the initial questionnaire for comparison with the development teachers. As part of this questionnaire they rated themselves on how confident they felt to tackle particular tasks using ICT. The following chart (Figure 6.3) is a summary of the average level of confidence reported by the 64 teachers who returned the questionnaire. The teachers' overall average confidence ratings are listed in increasing order. The lower down the list the more confident the teachers indicated they felt about tackling the task. The list suggests that confidence in using ICT is still a challenging issue for primary teachers. Only the final item, using a spelling checker, is an area where the average score indicates that teachers were confident to tackle the task.

Some interesting relationships with being a co-ordinator also emerged from this questionnaire. Perhaps unsurprisingly ICT co-ordinators have substantially better skills than others (with a mean self rating of 3.2 on our scale). Mathematics co-ordinators came next (self rating of 2.2) and English co-ordinators indicated that they felt they had relatively weak ICT skills, rating themselves lower, even on word processing, than mathematics co-ordinators (mean self-rating 1.7). Although the number of responses to the questionnaire was comparatively small (n = 64), these findings have implications for future training.

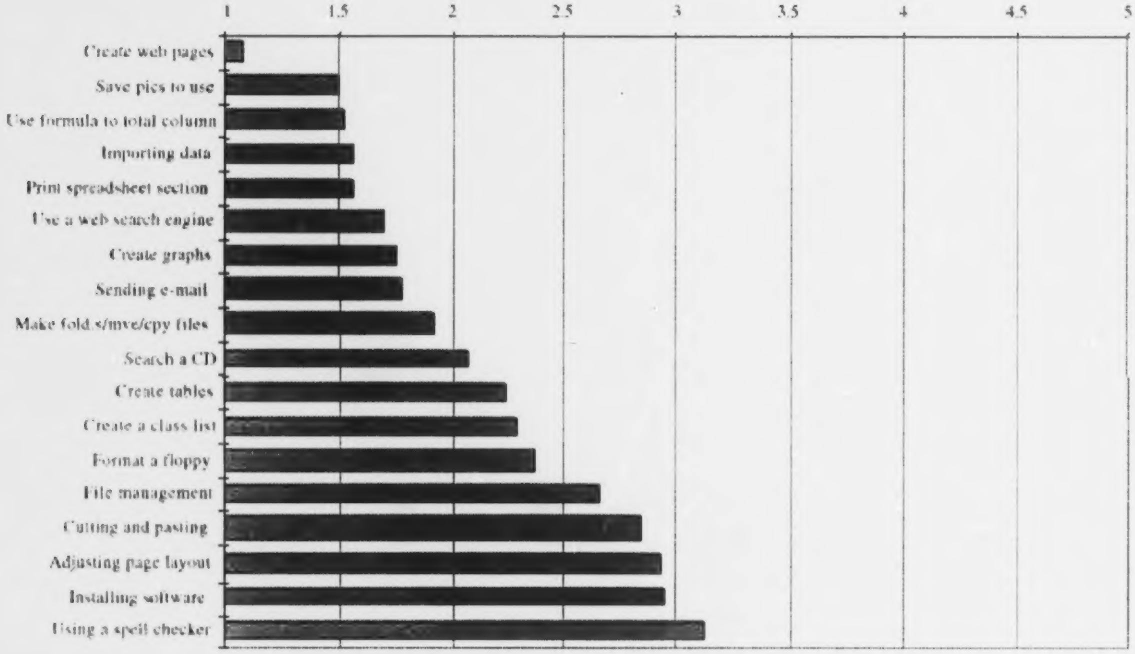

Figure 6.3: Teachers' self-reported confidence in ICT tasks (n = 64)

Impact of the development work

One of the aims of this second questionnaire (n = 64) was to identify any significant differences between a random sub-sample from the original questionnaire and the group of development teachers. Development teachers reported more change than other respondents between late 1997 and late 1998 in the following areas:

- more use of computers by teachers for whole class demonstration;
- less use of computers as a free choice activity;
- more time spent at computers by pupils (a 40% increase as opposed to an 11% increase for the non-development teachers);
- more use of computers to practise basic skills.

(NB We interpret this last item as the teachers identifying a clearer focus on the contribution of ICT to basic skills for literacy and numeracy, which was reported by the teachers in the final interviews, rather than an increased use of drill and practice software.)

The development teachers were also more likely to indicate that they believed that their level of skill was adequate for using ICT in their teaching and less likely to indicate that they had a limited grasp of ICT terminology. They also reported a significantly higher level of skills in half of the areas of technical skill on the questionnaire (10 out of 20 of the tasks).

Positive examples of tackling development issues

In the final interviews with the development teachers there was clear acknowledgement of the importance of pedagogical skills and understanding underlying the project, and the emphasis on effective use in the classroom which had had an impact on some of the teachers' thinking:

> "I might have used it and just let the children play on it in a way that it was more their ICT skill and not numeracy. Whereas I feel when was really planning well I was actually focusing on mathematical skills as opposed to ICT skills."
>
> "Certainly the project has been a driving force behind me making sure I am able to use the computer in a meaningful way, so the children can come into a lesson and I'm well focused and know exactly what they are going to be doing."

This factor was an important part of the development work. In many of the projects, once specific issues related to ICT had been overcome, the teachers and project team members were able to focus on the specific learning objectives within either literacy or numeracy which were the primary aim of the projects. Focusing on subject-specific objectives also enabled the team to work with teachers in developing their understanding in some areas of literacy and numeracy. ICT was therefore used as the vehicle for this subject-specific work but without this being explicitly identified as the focus for the development work. Given that most of the teachers did not rank the pedagogical or curriculum issues as important factors in limiting their use of ICT, this approach proved to be an effective way of tackling specific subject knowledge which was relevant to the learning objectives identified.

Tackling pupils' skills

One of the biggest difficulties for teachers in making effective use of ICT is a very basic one of first having to teach the children the necessary skills to use the technology. This clearly takes time and may not have a clear literacy or numeracy focus or objective. Addressing this issue, or at least making it explicit so that teachers can take it into account is therefore essential. A teaching objective in mathematics to develop pupils' understanding of the relationship between addition and multiplication in number needs to take into account pupils' familiarity with the operation of the software to be effective (see Section 2 'Developing mental calculation skills through pattern in number in Year 4' for the approach one teacher took in developing ICT skills and mathematical understanding). Similarly in teaching redrafting using a word processor pupils need to know not to press the return key at the end of each line and have an understanding of 'word-wrap'. This factor which is crucial in developing effective use of ICT in the classroom. Understanding the relationship between pupils' ICT skills and the subject-specific learning objectives of a task that a teacher has planned is vital. Addressing this skills issue begins to deal with some of the pupil-related time issues which teachers had also identified as obstacles needing to be overcome.

Teachers' comments

The final interviews with the development teachers also exemplify in concrete terms the kinds of activities which are useful in overcoming difficulties.

Supporting the development of pupils' skills to enable a clear focus on objectives in literacy or numeracy:

> "I think they are more confident in using the keyboard, and more confident in finding and using different functions."

Providing information about software, but again with specific subject-related objectives in mind:

> "I was really very much wanting to know about software, more than anything else really and luckily [the project team member] was able to introduce different software which I wasn't really aware of and gave me some interesting ideas on how to use it."

Offering prompt and uncritical technical support:

> "Especially with having [a project team member] as back up support, it has given me the opportunity to have a go at things. Sometimes technical support makes you feel like, well it's just not there most of the time, so I won't try anything different."

Supporting teachers' skills in using particular software which had a positive impact on teachers' attitudes and confidence:

> "Adjusting page layout and printing, because when we were using the scanner and Powerpoint, there was the chance to change things around and present them in different ways. Saving text and images to use in other software packages, there you go. I was really proud when I did that, I had to go and show everybody."

> "The spreadsheet, before the actual project, I couldn't use the spreadsheet as a number calculating tool at all, so I had to be shown how to do that. And creating graphs, I hadn't used spreadsheets at all, really. So I've learned a lot about spreadsheets."

Finding ways to increase access for pupils (in this case four laptops so that we could explore and illustrate how a teacher enabled a group to use ICT in the literacy hour):

> "The biggest difference is that we have more computers, more hardware. Normally we would possibly have two computers in the classroom, so that means that obviously two children or four children at the most would be having access at the same time. So having the extra computers has actually made it so much easier to integrate ICT into the literacy hour."

Buying copies of software for use at home:

> "I was able to put Textease on my computer at home, so I'm exploring a little bit more how to use it there as well."

This last comment can be interpreted another way, in that it is also an indication that this particular teacher was attempting to overcome the problem of insufficient time by increasing the amount of work he does at home.

To summarise this section, teachers identified ICT-specific issues as a major difficulty in their attempts to become more effective in using ICT in other curriculum subjects.

Supporting subject knowledge and pedagogy through ICT

The project team acknowledged these challenges (and worked to overcome them), but they also identified issues in subject knowledge and pedagogical approaches which also could be addressed. These issues of subject knowledge and pedagogy were often dealt with implicitly as part of the broader development work. For example in working on developing counting skills the diagnostic feedback from the baseline test enabled the teacher and project team member to discuss children's development of counting and devise some ICT activities in the light of this detailed information. Another example might be comparing solutions with and without ICT to specific teaching objectives such as when discussing how to improve number fact recall skills. The teacher and project worker discussed and identified other approaches such as using paired collaborative work and number games which did not involve ICT. The range of development work meant that it was difficult to address subject knowledge more directly in the project. As mentioned above, the team used the TTA's Needs Assessment materials in literacy and numeracy with the development teachers as part of the process of support and discussion. The main issue was in the perceived relevance of the specific subject knowledge involved. Teachers valued the materials particularly where the content was directly relevant to the age range and subject content that they were teaching. The development work in ICT was used as a vehicle for discussion of specific subject content and some broader aspects of pedagogy as they applied to the specific teaching and learning objectives with particular teachers which are evident in the illustrations of effective practice.

The work of the project team in tackling ICT-specific issues

In all the project schools there were some ICT-specific problems to overcome as an important part of tackling the effective integration of ICT into subject teaching. These varied from providing time for planning and developing skills with teachers, from teaching pupils the ICT skills needed to achieve literacy or numeracy objectives efficiently, to practical issues like installing software or providing ink cartridges for printers.

The project team members and teachers encountered and tackled all the issues mentioned above during the project. In some cases these difficulties were overcome relatively quickly and easily (e.g. providing some limited resources such as ink cartridges or buying extra copies of software). In a few instances the team supplemented the hardware available by supplying portables or palmtops to increase access for pupils. All of the teachers also had some time out of the classroom to plan work for the project and (in most cases) to learn particular skills which they subsequently developed over the course of the project (e.g. learning how to present information with slide shows).

In some cases the challenges were not overcome easily and required determined effort. Some of these were technical problems which had an impact on some aspects of the work with pupils (e.g. helping to sort out printer problems on a new network). Other problems such as more serious difficulties with new networks and delayed Internet connections meant that the on-line work we had planned to do with several schools just did not happen. The challenge of overcoming such problems specifically related to ICT should not be minimised.

Teachers' attitudes to ICT

The members of the project team have a further perspective to add about the teachers and their views about what stops them using ICT effectively in their subject teaching in literacy and numeracy. There is a clear perception amongst the team that these difficulties which we have outlined above are seen differently by different teachers, or affect different teachers in different ways. We have reported elsewhere in this report that there was a significant correlation between teacher effectiveness and certain attitudes towards ICT. Four items from the initial questionnaire in particular were strongly associated with the highly effective group of teachers. Teachers with high value-added scores tended:

- to report that computers made them feel good about their teaching;
- thought that computers did not require too much technical knowledge;
- said that computer software was not too complicated for children;
- provided activities for pupils to use away from the computer to support and extend their use of particular software.

Since these responses to the questionnaire were strongly associated with the highly effective teachers in this study (particularly with the 1996-7 data), it suggests to us that the highly effective teachers see the potential of the technology and try to use it effectively by integrating its use as part of their repertoire of teaching strategies and approaches.

Issues across the projects

In the same way the team feel that the challenges are seen by some teachers as something which is *to be* overcome and by others as more of a barrier which prevents them realising the potential of ICT. For these teachers development with ICT is a case of "rolling the stone uphill" (Leat 1999). For the former grouping, those who may have needed help at first, it is more a case of rolling a stone over the top of the hill. Once difficulties have been overcome, then the development work gains momentum and overcoming issues becomes less of a problem as the teacher's skills and confidence increase. The teacher who expressed her anxiety at using the school's new computer suite now regularly takes groups of her reception class, or even the whole class to use the cluster. On the other hand, for a few teachers in the project, once one problem was addressed and overcome, another appeared. Rolling the stone uphill in this case becomes more like the task of Sisyphus, as once your back is turned the stone seems to return to the bottom of the hill. The challenge is to provide effective assistance for teachers so that they feel confident to continue the process of experimentation and development themselves.

The school and the head teacher clearly play an important role in these different scenarios. In one of our schools the whole impetus of development seemed to increase as the project developed. Other teachers became involved and the development work which the project offered was expanded to support other initiatives the school was undertaking. Similarly in another school the head teacher worked with the project teacher to help her learn how to use presentational software and provided additional release time for her. This meant that the development work achieved more than had originally been planned. By contrast, after working with two teachers for over a term in a different school the teachers informed their project team member that they had in fact been 'volunteered' for the project rather than choosing to become involved as we had assumed. This may have explained why the development work seemed more difficult than had originally been anticipated.

The major challenges which teachers in the project perceived were preventing them using ICT more in their teaching of literacy and numeracy were centred around their own and their pupils' time to learn and use ICT. In addition difficulties with ICT hardware and software such as availability, reliability and access also posed some of the teachers serious challenges.

6.4 Some implications for development work involving ICT

Nearly all the teachers reported that they felt that they need assistance in incorporating ICT more effectively in their teaching (as opposed to learning further ICT-specific skills).

Schools will need to address the issues of availability, reliability and access to equipment for both teachers and pupils. In particular it is essential to deal with any problems or technical difficulties quickly if teachers are to reach the point where they can choose to use ICT in literacy or numeracy as the most efficient option.

Schools choosing to use ICT to support the teaching of literacy or numeracy will need to consider pupils' ICT skills as part of the development process. Targeting these skills with focused teaching (e.g. on a cluster in school or by visiting a cluster) may be necessary to enable pupils to achieve subject-specific objectives.

Some teachers will find the process of learning to use ICT effectively to support their teaching a particular challenge. Assisting them in overcoming difficulties will need careful planning and supportive implementation. It may be more effective to identify and to focus on a particular curriculum goal that ICT can help them achieve, rather than on ICT itself.

ICT can also be a broader development vehicle to investigate more effective learning within subjects. Using diagnostic information about pupils' achievements and difficulties (such as through standardised tests or a structure activity like a ten minute writing task) helps teachers to plan specific tasks involving ICT to achieve these objectives. These tasks then result in effective development of both ICT and subject-specific expertise. The illustrations above have examples of specific teaching and learning issues that our teachers chose to tackle with ICT. The descriptions also exemplified many of the issues in this section and the particular approaches the teachers and the project team used to overcome the challenges in the different teaching contexts.

6.5 Summary

- **Development work to improve effectiveness in teaching needs to take account of a number of areas in the research literature about teaching and learning.**
- **ICT then adds a further level of complexity to this process of change.**
- **The development work with teachers in this project tried to take account of a range of sources of information and worked with teachers pragmatically to support their choices about when, when not and how to use ICT in their teaching.**
- **This process involved negotiation, support, and feedback.**
- **Effective use of ICT demands technical support as well as individual competence.**

- **Ensuring that pupils have the required ICT skills to enable them to achieve subject-specific objectives is vital.**
- **Professional development and training in ICT also has the potential to support development in specific subject areas.**

Section 7: Conclusions and Implications

The aims of this section are to:

- **summarise the work of the project team in developing effective pedagogy using ICT in literacy and numeracy;**
- **identify some conclusions from the project and specific issues for those wishing to use the findings from the project to plan development work in ICT to support teaching in literacy and numeracy;**
- **identify some implications from this work which might be more generally applicable.**

We aimed to support the choices teachers make in deciding when, when not and how to use ICT to support their teaching of literacy and numeracy. Over the course of the project a substantial body of data was collected. These data provided a resource for the development work and ensured that the illustrations of effective practice were grounded in accurate information, particularly about pupils' attainment. The illustrations drew from this information and gave examples of how particular teachers in particular schools undertook development in extending their choices about the effective use of ICT to support specific teaching objectives. They are therefore only snapshots of development located in specific contexts. Some broader implications from the project can be identified which we hope will support teachers in other schools in trying to extend the range of choices available to them when using ICT to support their teaching in literacy and numeracy. We have framed these broader implications as issues requiring resolution. This is because we believe it will be necessary for teachers and trainers to address such issues if they are to undertake development work to improve pupils' attainment using ICT effectively in their own contexts. In addition, we try to suggest starting points for addressing those issues both from the report and in specific illustrations.

Provision and use of ICT

In this project we began by examining the use and provision of ICT in a range of primary schools in the autumn of 1997. Some of this information was updated in the following autumn. Most primary classrooms still have regular access to only one or two computers. This level of provision affects the choices teachers are able to make about how to use ICT effectively. There are clear patterns of use, which we identified in Section 2, and which can be identified from the information the teachers reported in the questionnaires. These patterns of use (e.g. as free choice, as an extension activity or as a reward) suggest that use of ICT is often not linked to subject teaching or specific learning objectives in literacy and numeracy. Few teachers regularly use ICT themselves in subject teaching to demonstrate to groups or to the whole class for example, though this type of use is increasing. Some schools have organised their equipment so that large groups of pupils or even whole classes can use computers at the same time. This is particularly efficient at developing pupils' (and teachers') skills in using ICT. This form of organisation may support more effective use of ICT in literacy and numeracy where schools co-ordinate the development of pupils' skills with the teaching of particular subject objectives.

Issues

- *What choices about effective use of ICT to support the teaching of literacy and numeracy does the available equipment allow (e.g. using ICT for working with groups or the whole class and using ICT to support pupils' learning in literacy and numeracy)?*
- *How will those choices be enhanced as new resources are acquired (e.g. by enabling planning for a group of pupils with more equipment, rather than just for one or two pupils at a time, or for an increased range of activities with the Internet, or whole class demonstration with a larger monitor)?*
- *What software applications lend themselves to support the development of more effective patterns of use (e.g. specific programs for demonstration in literacy and numeracy)?*

Developing more effective teaching

We found that teachers' thinking and beliefs about teaching and learning are linked to what they do in the classroom and affect the choices they make. Particular patterns of thinking and behaviour can be linked with the value-added measures of pupils' relative attainment, but no one pattern was clearly identifiable as more effective than another. The work on teachers' thinking suggests that some approaches will be more easily adopted by some teachers than others. For example, a teacher who favours whole class approaches may readily adopt the use of a presentation package using a number program. This might be to support development of mental calculation through making connections with number patterns, similar to the illustration 'Developing mental calculation skills through pattern in number in Year 4', but with the content of the activities taught as a whole class lesson. Alternatively a teacher who favours group work and discussion may prefer to start by using the computer to model writing with a group and then use the writing on screen as a focus for discussion of alternatives. This does not mean to say that both teachers would not benefit from being able to undertake both of the examples. In each case the teachers could move on to using ICT in either focused group teaching, or, once skills and confidence had been established, in whole class work. We are suggesting that the starting point for increasing the range of teaching approaches of individual teachers may usefully be in areas where teachers have a preferred approach or are already confident in their pedagogy. We believe that this is more likely to be successful and will encourage development more broadly.

Issues

- *How will a teacher's individual needs and preferences be taken into account? (What subject is a good starting point, and with which approaches are they already confident?)*

- *How can teachers then be supported in extending their repertoire of pedagogical approaches into areas where ICT offers particular strengths (e.g. using text-to-speech, teaching redrafting, or presenting texts to the whole class)?*

- *How can teachers and trainers identify which approaches are likely to be the best starting points for different teachers (i.e. by identifying how a teacher is currently using ICT and then what approaches may be developed from this starting point)?*

Developing ICT skills and subject effectiveness

Teachers are likely to identify ICT issues as preventing them from using ICT in their teaching. These issues, such as adequate access and specific technical difficulties, may present real obstacles which need to be overcome if teachers are to use ICT. Teachers are less likely to consider subject knowledge and application as a limiting factor in developing their effectiveness. However ICT can be an effective vehicle for the development of subject understanding and pedagogical content knowledge at the same time as ICT skills and confidence are increased. In the project we took the view that teachers were more likely to develop their ICT skills if they were then able to use those skills in their teaching, rather than developing their ICT skills in isolation.

Issues

- *How can issues relating to the reliability of ICT equipment and adequate access to such equipment be distinguished from pedagogical development needs and addressed separately? (What* ***kind*** *of support is needed - technical, specific ICT skills, ideas for activities, teaching strategies, subject-specific support?)*

- *What specific areas of literacy and numeracy or which parts of structured literacy and numeracy lessons can be supported by ICT for a particular teacher or year group (e.g. pupils reading more challenging texts independently with speech support or understanding the connection between numerical data in tables and graphs)?*

- *What areas of ICT skills can then best support teaching in literacy and numeracy (e.g. learning how to use presentation software to create a slide show of a text for a literacy lesson, then the (pedagogical) skills to use the presentation software with a class of pupils)?*

ICT for teaching

Some teachers identify pupils' IT capability as a key feature in their planning of activities involving ICT. This may exclude from their thinking other activities where ICT can contribute to subject-specific teaching objectives but where pupils' IT capability is not being directly developed.

Issues

- *How can teachers be supported in planning for their own use of ICT in their teaching in addition to the planning they already undertake for pupils' IT capability?*

- *What forms of assistance will support more effective use (e.g. developing skills through training, offering ideas about how to use ICT or providing prepared template files for easy adaptation, supplying new equipment (such as a larger monitor) or new software)?*

Raising levels of attainment

In the development projects both highly effective teachers and those identified as averagely effective were able to achieve substantial gains in pupils' attainment in the short term as measured by standardised tests.

In the development projects we believe ICT contributed to this gain where:

- clear subject-focused objectives had been identified;
- it was clear that the teacher could use the ICT activity to deliver those objectives;
- the teacher ensured that pupils had ICT skills that were sufficient to enable them to achieve the subject-specific objectives;
- pupils were given sufficient access to ICT to achieve the learning objectives.

Issues

- *Which teaching objectives can be supported with ICT?*
- *How will ICT make the achievement of these objectives more effective or more efficient?*
- *What skills will the teacher need to achieve this?*
- *What skills will the pupils need to achieve this?*
- *How will access to ICT be organised?*
- *How will the success of the approach be evaluated?*

School approaches

In some schools the support of the head teacher or the approach to collaborative working in the school enabled the impact of the development work to be greater than had been planned. This factor is established in the literature as an important part of effectiveness (Appendix 3). In this project we supported teachers at an individual level to become more effective in their choices about using ICT. Some issues did arise where it is clear that a co-ordinated approach would be beneficial.

Issues

- *How will the school co-ordinate the development of more effective use of ICT?*

- *What patterns of working are already in place which could support ICT development? What sort of balance will be achieved between formal support (e.g. identifying ICT for teaching in literacy and numeracy in weekly planning sheets) and informal development (e.g. supporting collaboration as it develops between teachers)?*

- *How will training be matched with the purchase of new equipment and software (i.e. what are the training and technical support issues of new purchases)?*

An on-going process of development

In the project we had an indication that supporting more effective use of ICT may need a long term approach. Nearly all of the teachers involved in the development work wanted to continue working with the project. These teachers valued the contribution ICT could make to their teaching and wanted to develop further. They acknowledged that ICT offered them a wider range of strategies and approaches from which an effective teacher could choose in deciding how to meet teaching and learning objectives in literacy and numeracy. Some of them felt confident in their own ICT skills, some felt they needed support in this area specifically. Most felt that they would still benefit from further support and they could identify what area of teaching they wished to develop next using ICT. This applied equally to those who had relatively advanced ICT skills which they used in their teaching as to those just beginning to use ICT to support their teaching of literacy or numeracy. In addition new equipment and software is becoming available all the time which will require new skills and will enable new pedagogical approaches to be developed. We were disappointed that we were not able to investigate the contribution that e-mail and the World Wide Web could make to literacy and numeracy teaching because of technical difficulties in the schools where such activities were planned. We did have an exciting glimpse of how new technologies might support teaching in one school which was using an interactive whiteboard (the school described in the illustration 'Using short rhymes and other texts to enhance reading comprehension in year 4'). This clearly offered opportunities to extend existing teaching approaches as well as developing new teaching practices. Other schools in the project provided a picture of what sort of impact more portable and interactive equipment might provide for teaching and learning. While a goal of getting teachers to start using ICT as an effective part of their teaching is relatively easily attained, and certain principles about when (and when not) to use ICT can be established so that it supports teaching and learning both effectively and efficiently, we suggest that the task of developing teachers' effectiveness in using ICT is a long term goal which needs long term planning and that developing such effectiveness needs to become established as a regular part of teachers' professional development. In the project we identified (in Section 5) from the literature on teacher development that the teachers themselves play an important part in this process. We therefore encouraged them to identify the subject area that they wanted to support with ICT and negotiated the precise focus of the development which would enable them to use ICT effectively in their teaching in their classrooms. We believe that this was an important factor in their success in raising pupils' attainment in literacy and numeracy.

Issues

- *How can teachers be helped to start the process of using ICT to support more effective teaching in the short term?*
- *How can the acquisition of new equipment and software in schools be co-ordinated with professional development in more effective use of this technology?*
- *What are the longer term implications for continued support in developing effectiveness with ICT?*

7.1 Summary

- The project involved the teachers in deciding the specific focus for development. This was to ensure that development work had clear literacy or numeracy teaching objectives and so that it was appropriate for their own teaching context, skills and expertise.
- Development work involving ICT can support more effective teaching in literacy and numeracy.
- ICT can contribute to effective teaching in literacy and numeracy where clear subject objectives have been identified.

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Appendix 1: Some results from the surveys and questionnaires

1.1 Summary of ICT equipment and use data from the first questionnaire (December 1997)

Identification of classes for further study

The three measures used in the sample selection were:

- level of ICT provision, giving double weight to computers in relation to computer peripherals and to a combined index of other digital devices;
- systematic use of ICT, based on reported evidence of well-planned and effective practice;
- class-level added value averaged for reading and maths (from the PIPS Project).

The 'provision' measure was somewhat of a catch-all, but reflects the broad definition of ICT which was under investigation. In fact the availability of free-standing digital devices that can be used with a focus on literacy (concept keyboards, hand-held spelling checkers, digital cameras and fax machines) did tend to be related.

The questionnaire asked for responses from teachers in four main areas:

- you and your class;
- provision and use of ICT equipment;
- curriculum use of ICT; and
- views and opinions about the educational use of ICT.

The questionnaire had 250 responses representing a 34% return rate. (Figures in different categories may not total 100% due to rounding.)

ICT equipment

Computers per class: modal number: one (26%). A further 25% had shared or full access to two computers. Only 3% had access to four or more computers.

Limitations of computer equipment: substantial numbers of older computers that lack hard disc and CD drives were in use. 31% of respondents had no access to machines with hard discs and 35% were unable to make use of CD roms.

Internet connections: only 10% of respondents were able to access the Internet from school, the majority of these from a single machine.

Integrated Learning Systems: 7% of respondents made use of ILS but only four schools (1.6%) had such software running on six or more machines.

Overlay/Concept keyboards: One or more were available to 60% of respondents, but 27% of Reception classes had none. The project team did not encounter these keyboards in use in any of the observation and development classes. The introduction of newer computers and software may be making some of the functions they served redundant (e.g. on-screen grids for text input, such as Clicker/CrickSoft).

Hand-held Spelling checkers: only 8% had any and only 2% have four or more (equivalent to one per table).

Calculators: 12% had none; 19% had access to 1-9; 20% had access to 10-14; 15% had access to 15-20; 19% had access to a class set (21-30+).

Turtles, Roamers, etc.: 10% had none; 83% had access to one or two; 7% had three or more.

Musical keyboards: 46% had none; 32% had one; 12% had two or three; 10% had four or more.

Digital cameras: 84% had none, while 15% had access to one.

Fax use by children: only 2% of the sample reported that faxes had been sent from school by children.

Use of computers

61% of teachers reported that the computer was in use *every day* by their pupils (28% reported only *several times per week*, 8% *several times per month* and 3% *less frequently*). When asked how often 'a typical pupil got a turn on the computer' the teachers reported 5% *every day*, 40% *several times per week*, 52% *several times per month* and 13% *less frequently*.

Systematic use

'Systematic use' was a composite variable made up of 10 quantitative and five scored qualitative items, reflecting planning, preparation of adapted and related activities, supervision, additional support and record-keeping. (These items formed a moderately consistent scale, with an internal consistency alpha coefficient of 0.64.) It is worth noting that 'systematic use' was not the same as 'high use', nor was it the opposite of 'incidental use'. In fact, the composite measure of 'systematic use' was unrelated to any of the following types of use: as a reward, after the completion of class work, as part of free-choice activities or at break time.

The original intention in the project was to investigate differences between classes with systematic use compared with a less systematic approach to using ICT, as well as between high and low value-added teachers. However, no link was found between 'systematic use' and PIPS value-added scores. Also, once the development work started we found that we could not sustain the systematic use category as a distinguishing characteristic. The project team therefore concentrated on the differences between the high and average value added teachers and the choices they made in the classroom.

Software used for numeracy

Only 87 of these 250 teachers indicated that they used computer software to support numeracy or number activities. The programs they specified are shown below. The chart clearly shows the preponderance of practice software (e.g. Animated Numbers for lower primary) but also indicates the use of a range of other types of programs.

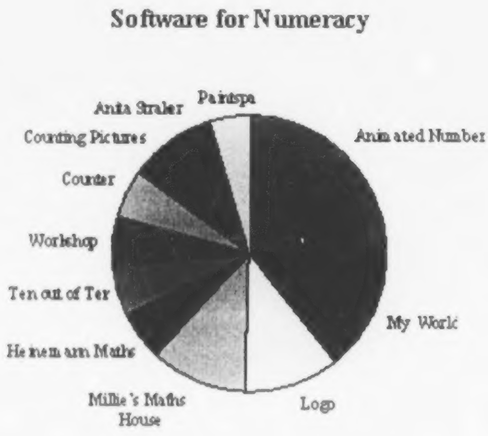

Figure A1.1 Software used for numeracy (n=87)

Software used for literacy

Out of the 250 responses, 175 teachers indicated that they used specific programs for literacy as indicated in the chart below. Various word-processors feature prominently, but so do more structured language programs.

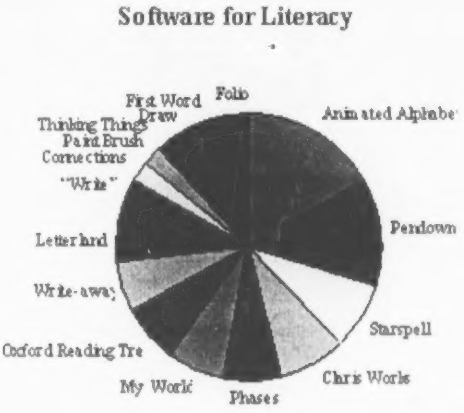

Figure A1.2: Software used for Literacy (n= 175)

Home use by teachers

63% of the teachers used a computer at home and, of these, 59% used it at home to help them with their school work. (See below for results of a smaller follow-up survey a year later which suggest that this snapshot of availability and use is changing rapidly).

1.2 Follow-up questionnaire (December 1998)

One year later (November/December 1998) a follow-up questionnaire was sent to a sub-sample of the first questionnaire respondents (64 returns, 53% return rate). The aim of this questionnaire was to see if there were any significant changes in use, attitude and provision over the course of the year and to make comparisons with the development teachers. Several overall changes were apparent.

Pupils' use

Only 53% of teachers reported that the computer was in use *every day* in December 1998, compared with 61% the previous year (32% *several times per week*, 10% *several times per month* and 3% *less frequently*). Estimates of a typical pupil's use had not, however, declined consistently with this (5% *every day*, 40% *several times per week*, 43% *several times per month* and 10% *less frequently*. To make the picture more complex teachers estimated that the average time per week a pupil would use a computer had increased slightly (28 minutes in 1997 to 32 minutes in 1998. None of these findings was easy to square with anecdotal reports from the development schools that teachers were finding it more difficult to incorporate computers into the pattern of a focused literacy and numeracy session. The increase in reported use may reflect the overall increase in equipment during this period of time. These difficulties in interpretation are also possibly partly due to some unreliability in the self-reported data and the smaller sub-sample in 1998. In addition there may have been some changes in practice in some primary classrooms with the implementation of the National Literacy Framework and National Numeracy Strategy which make it difficult to draw any firm conclusions.

Internet availability

In December 1998 37% of those surveyed said that they has access to a computer at school with an Internet connection (compared with 10% in 1997). The DfEE 'ICT in Schools' survey for 1998 reported that 17% of schools were connected to the Internet (http://www.dfee.gov.uk/ict/results.htm).

Home use by teachers

42% reported that they had an Internet connection at home, and only 27% said that they did NOT have access to a computer at home.

These figures clearly indicate a complex and changing picture of computer availability and use by teachers in the primary sector, both at school and at home.

1.3 How Y4 pupils see computers

One area that the team felt had been insufficiently explored in the course of the project was the views and attitudes of pupils about ICT. Teachers had told us that their pupils liked to learn with computers (with only 3% disagreeing and 5% unsure), but we had not compared the information from the teacher questionnaire with information from pupils. Towards the end of the project, the opportunity to do this arose in connection with a postgraduate research project. This research, from which questionnaire data was made available by Nadine Mearns, sought to study how pupils' school and home experience with computers influenced their attitude towards ICT. Questionnaire data were collected in February 1999 from 188 Y4-Y6 pupils in five of the project schools. However, the information presented here relates only to 95 Y4 pupils in those schools. Although four of the five classes were taken by teachers who had not participated in the project, the information about computer use could usefully be compared with the questionnaire data supplied by 11 Y4 teachers only one month earlier.

How much do Y4 pupils use computers?

Pupils and teachers agreed that one session per pupil per week was the most common arrangement, but the teachers' estimate of a mean of 51 minutes per pupil was probably on the high side. 28% of pupils said that they used a computer in school only once a fortnight or less. However, 70% of the pupils said they had a computer at home and daily use was the norm for these pupils.

For what purposes do Y4 pupils use computers?

In school, basic skill work, word-processing, extension and project work were the more common types of pupil use. Free choice and reward access as well as information retrieval and work with spreadsheets and databases were less common. In the home, games headed the list, then came CD roms used by many on a daily or weekly basis for finding things out. Using graphics in various ways was also a common occurrence at home, as was card design, drawing and manipulating pictures and text. Word processing and spell-checking was for about half of the pupils a regular activity, as was homework among the 35% of pupils who reported it. About 20% of those with home computers were regular users of the Internet or involved in programming, while 10-15% said they made regular use of spreadsheets and databases.

It is clear that for many pupils the frequency and range of computer use in the home greatly exceeded what was provided in school. Two areas where the differences were considerable were creating and handling graphics and finding things out by carrying out searches.

What do Y4 pupils think about using computers?

Of 20 attitude statements, the four that pupils agreed with most strongly were:

- *computers are exciting*
- *computers help to make your work look better*
- *computers can help me learn things about the world*
- *I enjoy using the computer.*

The four statements that received the least support were:

- *computers help me improve my reading*
- *it is faster to do my work using a computer*
- *I like to work in pairs on the computer*
- *my teacher gives me time in class to follow my own interests.*

It is clear that computers are popular with pupils and are seen as a tool for learning, despite some reservations about constraints on time and freedom and about value of computers in improving reading.

When the 20 statements were combined to form a scale, the items which were the best indicators of overall attitude were:

- *being able to use a computer will help me when I am older*
- *computers make it easier to do my work*
- *I like word-processing on the computer*
- *computers help me to do my homework*
- *computers help me to collect information.*

It can be seen that the pupils evaluated computers in instrumental terms, seeing them as relevant to their present and future work.

None of the above indicators was significantly more positive among the 66 pupils (70%) who had a personal computer at home, although the general trend was in that direction. Nor was the overall frequency of home computer use significantly associated with the pupils' attitude towards computers. So far as school use is concerned, the more frequent the use, the more pupils were likely to agree that (a) *computers help me to collect information*, and (b) *computers help me to do my homework.*

In what ways may the pupils' experience with computers have influenced their attitudes?

Examination of correlational links between attitude indicators and types of computer use led to the following generalisations and interpretations:

- pupils who often did word-processing at home were more likely to enjoy it, whereas this did not apply to the word-processing done at school, where, although pupils knew that word-processed work looks better, they tended not to enjoy sharing a computer with others;
- home and school use of computers for finding things out and for working with graphics were generally seen as useful and enjoyable by pupils;
- pupils who had experience of working with computer graphics and of using the Internet were not impressed with the speed at which they could work;
- pupils who had used computers for homework, whether in school or at home, thought that this was a good thing;
- pupils' experience of using spreadsheets and databases in school made them feel more competent with computers and made it more likely that they would recognise that having computer skills would help them in the future.

Summary

It appears that home computer use by pupils is increasing rapidly, as it is more generally by all age groups in society. Computers have a very positive image with pupils, which is largely independent of the amount of computer experience the pupils have. The educational uses of computers in the home are substantial for many pupils. School instruction in more demanding ICT skills is valued by pupils, who see it in instrumental terms. Pupils are rather more likely to enjoy using computers at home than at school. Opportunities for creating and handling graphics and for finding things out tend to be more limited in schools than in homes, at least for those who have the technical means and knowledge to do these things.

1.4 Pips value-added data

The project was fortunate in being able to validate key messages concerning effective teaching against relative performance data from the PIPS (Performance Indicators in Primary Schools) project about individual pupils. This information identifies the improvements in reading, number and attitude made over the previous year (in Reception) and over the previous two years (in Y2 and Y4). In calculating the value-added scores, pupil and school contextual factors are taken into account, so that like is compared with like. In the case of Reception teachers, the value-added score refers to the effectiveness of a particular teacher in the previous year; in Y2 and Y4 classes, the gains made reflect (in most cases) the efforts of two different teachers over the previous two-year period. The repeat of these measures over time, however, enables the relative effectiveness of teachers and schools to be identified.

Value-added statistics from 1996-7 were provided for 32 classes in which observations were carried out. Overall, there were 17 classes with value-added scores in the average range and 15 classes with high levels of value-added. These statistics were updated a year later with the data for the year in which the observations were conducted (1997-8).

PIPS is a professional monitoring project which is open to all primary schools. It is one of a family of similar secondary schools projects run from the CEM Centre at Durham University. PIPS tracks the progress and attitudes of pupils from entry to school at the age of 4 to the end of Year 6. Schools in the project received detailed feedback on their own provision and this includes value-added scores. The project continues to expand since its very small start in 1993 and now involves more than 4,500 schools.

Further details may be found by writing to PIPS project, Mountjoy 4, Science Site, Stockton Rd., Durham DH1 2UZ or from the web site: http://cem.dur.ac.uk/pips/ .The project has produced a steady stream of research papers based on PIPS data. These include, for example, Tymms, P.B., Merrell, C., and Henderson, B. (1997) 'The First Year at School: A quantitative investigation of the attainment and progress of pupils', Educational Research and Evaluation 3, 2:101-118.

Appendix 2: Existing research and publications about ICT, pedagogy and attainment

A wide range of sources of information has been researched for the project. The following list is not exhaustive but serves to illustrate the range of materials consulted:

- Articles from peer reviewed journals
- Articles from professional journals
- Books
- Databases of research findings on ICT
- EEC reports
- Government agency reports
- National Council for Educational Technology (now BECTA) reports
- Published case studies
- Reports commissioned by the leading hardware suppliers
- Sources on the WWW.

Over 200 sources were reviewed for the database. References to some specific publications are made here and full details of these are included at the end of this Appendix. They are mentioned to exemplify the kinds of publications referred to, or where they might be helpful for those wishing to pursue particular themes indicated. The team gathered information which might be helpful in supporting primary teachers' choices in using ICT to help improve pupils' attainment in literacy and numeracy. We did not conduct an extensive literature search on all aspects of ICT and teaching and learning. Some areas had been covered recently by other studies. Integrated Learning Systems for example were reviewed by BECTA (Wood, 1998) and by Underwood and Brown (1997). Other areas, such as research into higher education and ICT were only included where we felt it was relevant. One of the purposes of the research database was to provide sources of further reading materials for teachers referred to in the illustrations. The literature review therefore included professional journal articles as well as more theoretical academic papers.

Key messages arising from the literature about ICT and pedagogy

- Publications on the use of ICT in education have traditionally suffered from an excessive optimism with a high proportion of the information being uncritical and prescriptive.

- The majority of studies involving pupils do not emanate from teachers in classrooms but are experimental in nature often using software designed or refined by the researcher. These can be seen in many cases to be testing aspects of learning theory, particularly from a psychological perspective, which offer valuable insights into learning at an individual level. It is not always clear that the findings will translate into easy messages for more effective teaching at a class le

- The research reviewed suggests that when researchers initiate ICT activities for pupils they tend to use computer assisted instruction or computer assisted learning software where learning content is presented to pupils. By contrast, when teachers carry out action research, the preferred choice is more open ended or generic software.

- There is tension in the literature between those who believe computers should help teachers do their jobs as they do them now and those who see computers as redefining teachers' roles with a move towards resource management and more independent learning by pupils.

- Reports published by major hardware companies (often very accessible and well presented) unsurprisingly paint a glowing picture of using computers in the classroom. Many of the reported gains in achievement are based on anecdotal evidence although this is not always evident when reading the reports.

- The scale of research into computer assisted instruction (CAI) is staggering. One study (Fletcher-Flynn and Gravatt 1995) into the efficacy of CAI limited studies it examined to those that took place between 1987- 1992 - almost 400 studies met this criteria. In this particular meta-analysis of CAI the mean effect size was (.24) for the five years in question and (.33) for the more recent studies. This suggests two things: first, it is possible that CAI may be becoming more effective; second, that CAI only produces relatively small improvement. Peer tutoring, reciprocal teaching and homework, for example, all produce larger effect sizes (Hattie 1987).

- The use of computers to present information to pupils is often considered to have certain advantages over traditional methods. One claimed benefit is that computers can give immediate feedback about the correctness of a response. There is however disagreement in the literature as to the benefit of immediate feedback when pupils are working on a computer (e.g. Messer *et al.* 1996). This suggests that it is the quality rather than the availability of feedback which is important.

- An identified benefit of ILS is the increased amount of practice pupils get, and some researchers have suggested that this may be a crucial factor in its impact on pupils' attainment (e.g. Underwood and Brown 1997). This may also explain the beneficial impact of other ICT projects which have shown that ICT increases pupils' attainment. Pupils may have improved because they spent more time working at or practising the skills being investigated. Use of ICT can clearly be effective in improving pupils' performance. However, such positive results do not help a teacher decide if the use of ICT is *efficient*, as other methods or approaches (e.g. reciprocal teaching) may similarly increase the amount of time pupils spend actually engaged in learning particular skills.

- Group work with computers has been given considerable attention in the literature, although much of it is descriptive. Where testing has occurred it is suggested that individuals perform better than groups when carrying out drill and practice activities (e.g. Jackson and Kutnick 1996). There is also evidence that computers can be used effectively to support pupils' reasoning and talk when pupils work on collaborative tasks (e.g. Wegerif and Scrimshaw 1997) and that the nature of the talk is not necessarily dependent upon how 'directive' the software is. However teachers may well need to teach pupils how to interact with each other more effectively when using the computer (Eraut 1995). This suggests that effective use of ICT needs to take into account the aims of an activity and that grouping pupils when using computers requires a deliberate choice according to those aims.

- Much of the research into use of computers in classrooms is based on survey methods involving self-assessment and self-reporting by teachers. Little direct observational research has taken place. Where observations have been carried out researchers noted little computer use with drill and practice and typing up of 'a best copy' as the prevalent activities (Chalkey and Nicholas 1997). In the recent update of the ORACLE project (Galton *et al.* 1999) conducted a large number of observations in primary classrooms between 1996-7. Of almost 1000 pupil observations only 12 involved pupils using ICT. The authors do note that their sampling method may have under-represented the actual time pupils use ICT as they focused on individuals. However it still suggests overall use by pupils is very low.

- Knowledge of, and experience with, computers are not enough to ensure that teachers use computers in the classroom. The shift to using computers within the classroom takes time (Somekh and Davis 1997) with one study suggesting that up to a year was necessary with the support and encouragement of an experienced team. In addition the way in which teachers skills, beliefs and practices are related is complex (Wild 1996)

- The time lag between research carried out and publication in peer reviewed journals would appear to be, on average, about two years (in some cases it is much longer). This means little has yet surfaced on the use of the Internet or surprisingly, the use of multimedia. This contrasts sharply with reporting in newspapers and professional journals and material available on the Internet itself. The approach of some journals and research funders to make detailed findings available on the web more quickly is clearly to be welcomed (e.g. Williams *et al.* 1998).

The database

The initial literature search revealed a large amount of material about ICT and teaching and learning. A disappointingly small proportion of this is empirically based and an even smaller proportion looks at pupil improvement through identified gain, particularly for the primary age range. We did not find any studies to date about ICT in primary schools which link teacher development and pupil attainment data. Nor did we find any intervention studies which took initial observational data on the use of ICT in classrooms as a baseline before development or intervention work started and which again reported impact on pupils' attainment.

Potential benefits or 'hotspots' for support with ICT

Many of the research studies report the beneficial effects of the computer on pupils' literacy skills. This has either been through speech feedback in a word-processor used to improve reading (e.g. Hartas and Moseley 1993, Davidson and Noyes 1995) or speech in interactive storybooks (e.g. Taylor 1996, Collins *et al.* 1997, Medwell 1998) or more recently speech input (Miles *et al.* 1998) to support pupils' literacy skills. The combination of speech and text for pupils was therefore one area in particular which we thought would be beneficial for literacy. Even here, however, a clear progression was suggested by the literature. The addition of speech for word recognition could clearly help beginning readers, such as in a talking story book. For pupils focusing on writing and spelling speech support provided a way of encouraging pupils to re-read (or have the computer read) their work to identify where improvement was possible. For more fluent readers speech support provides a way of extending the challenge of reading materials (either by spoken support for new words or to provide dictionary support to increase comprehension). Fluent readers should be able to read a text more quickly than a computer (or human) can read it aloud. This means that there are likely to be limits as to how useful speech support might be. The indication in the literature that speech support was beneficial needed further analysis to understand where, how and for which pupils it might be helpful.

In mathematics the research evidence was less convincing (Higgins and Mujis 1999), though again there were specific examples of research (excluding calculators and ILS) which suggested ICT could be beneficial (e.g. Hativa and Cohen 1995, Ainsworth *et al.* 1998).

One of the inferences we drew from this research base was that ICT was powerful in presenting or representing information in different ways (e.g. Ainsworth et al. 1997). This might be through speech and text, or text and pictures for literacy and pictures and numerals or through tables and graphs for numeracy.

ICT clearly also has potential to represent information dynamically so that the learner can make changes easily and evaluate the effect of those changes in one representation (e.g. in word-processing (Snyder 1993, Breese et al. 1996) and in spreadsheets (Mann and Tall 1992)) or between representations (e.g. Ainsworth et al. 1997). This might be in identifying changes in a graph when changes have been made to a table of numerical information on which the graph was based.

The overall conclusion reached from the analysis of the available literature suggested that there were clear possibilities for ICT to have an impact upon pupils' attainment, but that there were no guaranteed solutions as to what would work in a particular context.

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Appendix 3: A brief review of research on effective pedagogy

The aim of this appendix is to:

- **provide information about the rationale behind the observational instruments used in the project;**
- **make explicit the research on effective teaching behaviours which underpinned the development work;**
- **summarise some of the literature on effective teaching and the relationships with ICT.**

Introduction

This report is concerned with investigating effective pedagogy, focusing on the use of ICT in the teaching of literacy and numeracy in primary schools. We took as our starting point a definition of pedagogy as being 'the science of the art of teaching' (from Gage and Simon quoted in Galton *et al.* (1999), p.183) It was therefore necessary to review the research on classroom interaction and the findings on effective teaching that emerge from such research into effective pedagogy, and to critically evaluate the appropriateness of various methodological approaches to classroom interaction. This was to provide a clear rationale for the choice of research design and methodologies used in the current study. This research project, however, sought to illustrate effective teachers' choices about when, how and when not to use ICT as part of their repertoire of pedagogical approaches. The literature reviewed here helps to set this research in context and identifies as the starting point that the purpose of understanding different pedagogical approaches is in order to match approaches with specific learning objectives. It must be borne in mind that learning objectives need to be considered within a specific time frame. This may be either short, and achievable within a lesson or two, medium, over a series of lessons or weeks, or long term, over the course of months or a year or even longer. Clearly, in the context of this study we are considering that match in the short to medium term and the choices that teachers make within this time period. The research on effective teachers and teaching indicates which approaches are most *likely* to be successful in a new context. However any such informed choice must also evaluate to what extent those choices were successful in that new context and whether any alternatives offer the possibility of greater success, either in the short, medium or longer term.

Knowing what to teach - Subject knowledge

Teachers need knowledge and understanding of what they are going to teach. This subject or content knowledge forms the basis of the curriculum. As part of the development work in the project, the teachers used the TTA's needs assessment materials for literacy and numeracy as a basis for discussion with members of the project team. The individual development projects also involved discussion of subject-specific knowledge between the teachers and project team members (for instance the work described in 'Developing counting skills with Reception pupils' draws upon specific mathematical knowledge about how young children learn to count). The breadth of the development projects involved identifying specific subject objectives and discussion of detailed areas of particular subject knowledge in literacy and numeracy in the primary curriculum from Reception to Year 5.

Knowing what to teach - subject principles

The King's College study of Effective Teachers of Numeracy (Askew, Brown *et al.* 1997) demonstrated that it is also teachers' awareness of the connections and relationships within a subject which contribute to their effectiveness.

The model used in this study(Figure A3.1) maps out the relationship between teachers' underpinning beliefs in numeracy as well as their mathematical subject knowledge in an important way. One of their conclusions was that "teachers' beliefs and understandings of the mathematical and pedagogical purposes behind particular classroom practices seemed to be more important than the forms of practice themselves". These beliefs and understandings must, however, be evident in teachers' actions in order to have an effect. That direct effect is hard to identify using the observational techniques in classroom over a short period of time, although the previous section indicates that it is possible to establish some links between a teacher's approach to teaching and observable teaching behaviours.

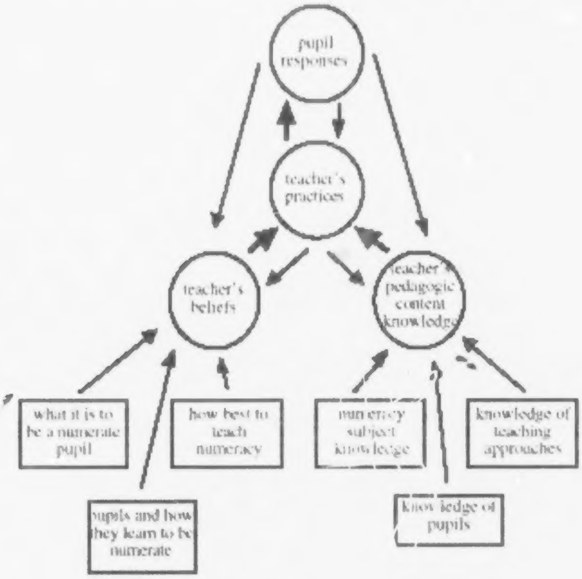
pupil responses
teacher's practices
teacher's beliefs
teacher's pedagogic content knowledge
what it is to be a numerate pupil
how best to teach numeracy
pupils and how they learn to be numerate
numeracy subject knowledge
knowledge of teaching approaches
knowledge of pupils

Figure A3.1: The model of the relationships between beliefs, knowledge and classroom practices in numeracy in Askew, Brown et al.

Exeter University's 'Effective Teachers of Literacy' report (Medwell, Wray *et al.* 1998) also concluded that both knowledge and pedagogical understanding are important, particularly the connections between different aspects of literacy in primary teaching. For example, in English explaining relationships between word and sentence level work within a text level approach was identified as an important aspect of a teacher's effectiveness. The report concluded that it was because of this knowledge of their subject that "they were able to see, and help their pupils see, connections between the text, sentence and word levels of language".

Understanding pupils

Pupils are also starting from different points in their experience and learning. There are, therefore, important social and psychological aspects of teaching and learning (see, for example, Wood (1998) for a summary). An effective teacher will seek to create optimal conditions for learning for pupils from differing backgrounds and with different personal characteristics, competences and knowledge. Borich (1996), for example, presents his account of some of the implications of socio-economic status of pupils for teachers and Aubrey (1997) presents some implications of the knowledge of mathematics that different Reception pupils have on entry to school. Designing the teaching strategies which will be most efficient or effective in balancing the needs of the majority and the particular or special needs of individuals is a challenge for all teachers.

Knowing how to teach content to pupils

How teachers decide they are going to teach subject content is determined by their knowledge, understanding and experience of the process of teaching children. This is sometimes called pedagogical content knowledge following Schulman's work (1986). It involves knowledge and understanding of both content and children:

> "the most regularly taught topics in one's subject area, the most useful forms of representation of those ideas, the most powerful analogies, illustrations, examples, explanations and demonstrations- in a word, the ways of representing and formulating the subject that make it comprehensible to others....it also includes an understanding of what makes the learning of specific concepts easy or difficult: the conceptions and preconceptions that students of different ages and backgrounds bring with them to the learning."

(Schulman, 1986, p 6)

We interpret the consistent strand of highly effective teachers' behaviours, which we summarised above as the ability to provide effective explanations, as supporting Schulman's belief in the importance of this pedagogical content knowledge.

It is clear from research (such as the Effective Teachers of Numeracy study mentioned above) that these areas of knowledge are important in effective teaching: knowledge of content, or the subject being taught; knowledge about the way pupils learn and then the combination of these: the way to teach *particular* content to *particular* pupils. The decisions and choices that effective teachers make are based on personal experience and their particular understanding of the content being taught, their knowledge of the pupils and the best way to present that content. Issues to do with organisation and the practicalities of managing teaching are important too, and this craft knowledge is what teachers use to make rapid decisions and is perhaps what helps teachers to be efficient. Brown and McIntyre

(1993) show how teachers tend to evaluate their teaching in terms of what pupils do rather than evaluating their own behaviours, and tend to describe 'normal desirable states of pupil activity' related to relatively short term outcomes. In the model of teaching and learning used in the project, these factors represent one strand across the model, and the skills and knowledge at this level affect the decisions teachers make about their teaching.

Bringing about change

As with children's learning, the affective aspects of professional development are extremely important. Teachers' willingness to take risks and engage in a process of change is affected by their confidence, enthusiasm and motivation. All of these areas overlap and are interrelated. A conceptual model of competence is one way of understanding the interrelationships, particularly from a developmental perspective (e.g. Leat, 1993). This approach suggests that competence lies in the intersection of behaviours, knowledge and feelings. Teachers feel competent when they have adequate knowledge, adopt appropriate behaviours and are affectively comfortable. When they make a change in their practice they may have to give up some of the value of their existing craft knowledge to make the new approach work.

When development takes place a teacher starts to act outside this central area of perceived competence. This could be as a result of new knowledge, or attempting to try out new strategies and behaviours in the classroom. The change easily leads to feelings of discomfort. The resulting tension can mean that the aims of development are not achieved as a teacher struggles to act in the area of perceived 'competence'. If assimilating new knowledge or new teaching behaviours is too challenging then the easiest way to achieve a feeling of competence is to return to the previous comfortable state and reject the change.

This is particularly true with ICT. Our research found a link between teachers' attitudes to ICT, their self-reported skills and their effectiveness (see Appendix 4 for further details). At one level this was quite general. The first questionnaire found that teachers who said ICT made them feel good about their teaching tended to be the more effective teachers! This relationship was explored further in our sample of development teachers in their self-rating in using different ICT skills. The more effective teachers reported that they were able to undertake more challenging ICT tasks (e.g. using a database or spreadsheet). One explanation is that more effective teachers work harder at keeping themselves up to date with developments, or are more prepared to risk stepping outside their area of perceived competence in order to try to improve, and that their attitudes to ICT are a reflection of their skills and willingness to try to improve. This interpretation is supported by the experience of the project team when working with some of the highly effective teachers. Some of these teachers appeared not to be confident in their own abilities and were prepared to try new ideas and approaches (albeit critically) to see if they could improve pupils' attainment. The willingness of these teachers to take risks to bring about improved learning was a characteristic of effectiveness which the team discussed. Where they were confident in their ICT skills, or were offered support when necessary, they were willing to try new approaches and adopt or adapt these approaches as they saw necessary. The use of ICT in the classroom is also dependent upon a teacher's particular skill and confidence in using the technology and in understanding how it can be beneficial. For this project it added a further dimension which made deciding how and what to record about the teachers in the case studies both complex and crucial. Our intention was to capture aspects of the development that might act as effective catalysts for change for other teachers. This was initially to support the development work within the project, but also to capture aspects of the development to inform teachers more broadly as part of the dissemination of the research. The development of the illustrations of effective practice was the result of this work (see main report, Section 2).

Little research data has yet emerged on how ICT might contribute to effective pedagogy, though plenty of speculation is available. Some researchers argue (with data) that ICT has the potential to support current pedagogy and improve attainment within the frameworks that schools already operate (e.g. Underwood and Brown (1997) on the role of ILS). Others speculate that new pedagogies will emerge replacing the old (e.g. Papert, 1993). There is, however, growing evidence that existing approaches to teaching and learning have a powerful inertia and that schools tend to *assimilate* rather than *accommodate* new approaches, particularly with ICT (Tyack and Cuban, 1995). Some research suggests that ICT may have specific solutions to particular teaching and learning problems (e.g. Ainsworth *et al.* (1997). In this project we adopted a pragmatic approach and investigated how current technologies might best support current pedagogy, particularly in literacy and numeracy. To do this we developed observational instruments which drew on the research into school and teacher effectiveness, then used this information to discuss with the development teachers aspects of their practice and their choices and decisions about their teaching. A review of effective teaching therefore seemed in order.

In the last fifteen years, school effectiveness research has identified important factors at the school level which contribute to educational attainment (e.g. Rutter *et al.*, 1983; Mortimore *et al.*, 1988). However, in recent years research has turned its attention to teacher effectiveness because of the wide variation that has been found within schools, which is often greater than the variation between schools (Fitz-Gibbon, 1997).

3.1 Research on effective teaching behaviours

From the research into classroom interaction, five effective teaching behaviours have been identified that researchers generally agree contribute to learning gain, regardless of context, as measured by classroom assessment and standardised tests (Galton *et al.*, 1980; Brophy & Good, 1986; Good & Brophy 1991; Walberg, 1986; Croll & Moses, 1988, Mortimore *et al.*, 1988, Brophy, 1986; Pollard *et al.*, 1994). The effective teaching behaviours identified in the research are as follows:

- lesson clarity;
- instructional variety;
- teacher task orientation;
- engagement in the learning process;
- pupil success rate.

Lesson clarity

This key behaviour refers to how clear and interpretable a presentation is to the class. Research on clarity suggests teachers vary considerably on this behaviour: not all teachers are able to communicate clearly and directly to their pupils without wandering, speaking above pupils' levels of comprehension, or using speech patterns that impair the clarity of what is presented. Some indications of a lack of clarity (Brown & Wragg, 1993: Dillon, 1988) follow:

- the extent to which a teacher uses vague, ambiguous, or indefinite language ('might probably be', tends to suggest', 'could possibly happen');
- the extent to which a teacher uses overly complicated sentences ('there are many important reasons for eating food but some are more important than others, so let's start with those that are thought to be important but really aren't')
- the extent to which a teacher gives directions that often result in pupil requests for clarification.

Teachers who teach with a high degree of clarity have been found to spend less time going over material and their questions are answered correctly the first time, allowing more time for instruction. Clarity is a complex behaviour because it is related to many other cognitive behaviours such as the content, lesson familiarity, and delivery strategies (e.g. whether the teacher uses a discussion, direct instruction or lecture approach, question-and-answer, or small-group format). Nevertheless, research shows that both the cognitive clarity and oral clarity of presentations vary substantially among teachers. This in turn produces differences in pupil performance on cognitive tests of achievement (Borich, 1996).

Achievement is maximised when the teacher not only actively presents the material, but does so in a structured way, such as by beginning with an overview and/or review of objectives. Effective teachers tend to outline the content to be covered and signal transitions between lesson parts. Attention is drawn to the most important ideas and subparts of the lesson are summarised as it proceeds. The main ideas are reviewed at the end of the lesson. In this way, the information is not only better remembered by the pupils, but is also more easily apprehended as an integrated whole, with recognition of the relationship between the parts. It is also important to explain not just how, but why, procedures work (Brophy and Good, 1986; Lampert, 1988).

Pupil achievement has been found to be higher when information is presented with a certain amount of redundancy, particularly in the form of repeating and reviewing general rules and key concepts. Information needs to be presented with a high degree of clarity and enthusiasm. As far as pacing goes, the research suggests that for younger pupils and for basic skills, a brisk pace which helps to maintain lesson momentum and attention has been found to be most effective, while for older pupils, or where teachers have to make more abstract presentations of more complex and abstract subject matter, it may be necessary to move at a slower pace to allow more time for understanding to develop (Brophy and Good, 1986; Good, Grouws and Ebmeier, 1983; Lampert, 1988; Walberg, 1986).

This focus on the teacher presenting material in an active way to pupils should, however, not be equated to a traditional 'lecturing and drill' approach in which the pupils remain passive. Active teachers ask a lot of questions (more than other teachers), and involve pupils in class discussion. In this way, pupils are kept involved in the lesson and the teacher has the chance to monitor children's understanding of the concepts taught. Individual work is only assigned after the teacher has made sure pupils have grasped the material sufficiently to be ready for it. In general, effective teachers have been found to teach a concept, then ask questions to test children's understanding, and if the material did not seem well understood, to re-teach the concept, followed by more monitoring. Teachers must provide substantive feedback to pupils resulting from either pupils questions or answers to teacher questions (Brophy and Good, 1986; Good, Grouws & Ebmeier, 1983; Brophy, 1986).

To summarise, the research literature suggests the effective teacher:

- informs learners of the lesson objectives (e.g. describes what behaviours will be tested or required on future assignments as result of the lesson);
- provides learners with an organising structure (e.g. places lesson in perspective of past and/or future lesson);
- checks for prior learning relevant to the task at beginning of lesson (e.g. determines level of understanding of prerequisite facts or concepts and re-teaches if necessary);
- gives directives slowly and distinctly (e.g. repeats directives when needed or divides them into smaller pieces);
- knows the current attainment levels of pupils and teaches at or slightly above learners' current level of functioning (e.g. knows pupils and how to pitch the content of a lesson);
- uses examples, illustrations, and demonstrations to explain and clarify (e.g. uses visual props to help interpret and reinforce main points);
- provides review or summary at end of each lesson.

Instructional variety

This key behaviour refers to the variability or flexibility of delivery during the presentation of a lesson. For example, it might includes the planned mixture of different classroom approaches. Research indicates increased pupil achievement from the use of variety in instructional materials and techniques, the frequency and variety of reinforcement used, and types of feedback given to pupils (Brophy & Good, 1986). In terms of ICT, the use of technology clearly adds both to the range of approaches (e.g. using an Integrated Learning System) and to the variety possible within any particular approach (e.g. teacher demonstration using an interactive whiteboard). Effectiveness is therefore the appropriate choice of approach to match a particular context.

Teachers' questions

One of the most effective ways of creating variety during instruction is to ask questions. Many different types of questions can be asked, and when integrated into the pacing and sequencing of a lesson, they create meaningful variation (Kerry, 1982; Brown and Wragg, 1993). Therefore the effective teacher needs to know the art of asking questions and how to discriminate among different question formats: fact questions, process questions, convergent questions, divergent questions. It also involves knowing how to respond to pupils' answers so as to incorporate them into the discussion and open up opportunities for greater pupil participation (Dillon, 1994).

Dillon (1994) suggests a range of alternatives to questioning, what he terms 'non-question moves'. These are designed to act as a model of exemplary discussion behaviours for pupils for the way they should talk in a discussion. In reviewing the strategies Dillon suggests that in general, following a contribution to the discussion on the question under consideration, the other participants have four broad choices, each with several specifics to choose from: they can ask a question about what the speaker has said; make a statement in relation to what the speaker has just said; give a signal of receiving what the speaker is saying; maintain an attentive silence. In using these strategies Dillon argues that the teacher's lead and example will be helpful to the pupils in modelling and fostering appropriate discussion behaviour and in encouraging pupil questions. Therefore participants in this kind of classroom discourse have five broad choices: teacher questions, pupil questions, statements, signals and silences.

Similarly, Wood (1992) suggests that in order for pupils to take the initiative, the balance of control needs to be shifted in their direction, the achievement of which demands attention to a teacher's use of questions and alternative conversational tactics to a lecturing approach. His alternative discourse strategies involve 'low control' moves from teachers whereby instead of asking frequent questions they give their own thought and ideas in which they speculate, surmise, interpret, illustrate, or simply listen and acknowledge what pupils have to say. These alternatives to teacher questions which include telling, suggesting, negotiating and listening are designed to free pupils to give their own views, to reveal their knowledge and uncertainties, and to seek information and explanation through questions of their own. Once the pupils have helped to shape the verbal agenda, teacher questions are more likely to involve a genuine attempt to explore their knowledge and ideas.

Nystrand and Gamoran (1991) advocate that teachers pay more attention to the way in which they evaluate pupil responses so that there is more 'high-level evaluation' whereby teachers incorporate pupils' answers into subsequent questions. In this process called *uptake*, many of the teacher's questions are seen as being *authentic* in that they are shaped by what immediately precedes them. This is in contrast to recitation where there is usually a prepared list of *test* questions with pre-specified answers from a list of 'essential' information and knowledge against which a pupil's knowledge can be checked. It is suggested that through this process teachers can engage pupils in a probing and extended discussion in which they signal to them their interest in what they think and not just whether they know and can report what someone else thinks or has said. Therefore, when *high level evaluation* and *uptake* occur the teacher ratifies the importance of a pupils' response and allows it to modify or affect the course of the discussion in some way. Thus the responses are incorporated into an unfolding exchange which links together teacher questions and pupil responses so that it takes on a conversation-like quality in which the linkages contribute to the coherence.

Wells (1993) suggests teachers can make different use of the *feedback* move in the recitation cycle beyond the evaluative move for checking pupils' knowledge. He argues that the third move can be used to extend the pupils' answer, to draw out its significance, or to make connections with other parts of the pupils' total experience during lesson topics so as to create a greater equality of participation. Such episodes are marked by 'common points of reference' where everyone had 'relevant personal experience of the shared activities from which to construct common knowledge' (p. 30). Therefore, teachers can provide extending rather than evaluating feedback so that 'it is in this third step in the *co-construction* of meaning that the next cycle of the learning-and-teaching spiral has its point of departure' (p. 35).

Another helping behaviour is 'probing' (Borich, 1996). Probing refers to teacher statements that encourage pupils to elaborate upon an answer, either their own or another pupil's. Probing may take the form of a general question or can include other expressions that elicit clarification of an answer, solicit additional information about a response, or redirect a pupil's response in a more fruitful direction. Probing is often used to shift a discussion to some higher thought level.

Because research suggests there is no simple picture of the most functional cognitive level of questions and statements, it would seem that the best strategy is to use a mix of low and higher level questions and statements, the mix depending on lesson goal and subject content: more cognitively complex subjects demanding more higher level questions and statements. The optimal post-question 'wait time' similarly depends on context: when testing basic skills which should be automatic, a short waiting time is appropriate; however, when asking more cognitively demanding questions, or questions that are meant to elicit group exploration or discussion, a longer wait time is appropriate. Effective teachers have been found to ask more 'process' questions (i.e. questions calling for explanations by the pupils), though the majority of questions asked were still 'product' questions (i.e. calling for a single, easily evaluated, response) (Brophy and Good, 1986, Good and Brophy, 1991).

Brophy and Good (1986) suggest that if the pupil gives a partly correct answer, the teacher must affirm the correct part and then follow-up by giving clues and rephrasing the question. The teacher should initially try and let the pupil who provided the answer solve it further, rather than turning to other pupils. If this does not succeed, other pupils should be allowed to try and find the rest of the answer.

Feedback to learners is important. If pupils give an incorrect response, the teacher should indicate this. This can be done in the form of a simple negation, and not in the form of personal criticism (except when the failure to answer was clearly the result of inattention or lack of effort). Personal criticism of the pupils should be avoided as, if wrong answers elicit such responses, pupils, especially the less confident and able, will be reluctant to participate in class discussion or offer solutions. This should be avoided. The teacher should rephrase the incorrectly answered question or give clues to attempt to enable the pupil to answer it correctly. If this does not succeed, the question should be turned over to another pupil. It can be important when the right answer is found to explain why this answer is right, and also why the previous was incorrect. In general, effective teachers have been found to provide more feedback than less effective teachers (Brophy and Good, 1986).

Dillon's (1994) work suggest that pupils should be encouraged to ask questions (as long as they are not intended to waste time). These questions should be redirected to the class before being answered by other pupils or the teacher, and relevant comments by pupils should be incorporated into the lesson, especially as for older pupils or those more experienced at contributing ideas. Overall, it is clear that effective teaching is not only active, but interactive (Brophy and Good, 1986; Nystrand and Gamoran, 1991).

Another aspect of variety in teaching is perhaps the most obvious, particularly in the context of ICT: the use of learning materials, equipment, displays, and space in the classroom. The physical texture and visual variety of the classroom can actually encourage pupil involvement with lesson content. The display of reading materials, use of audio and visual devices, demonstration materials, and the organisation of reference materials and learning resources can all contribute to instructional variety. For example, some studies found the amount of disruptive behaviour to be less in classrooms that had more varied activities and materials (Wragg, 1993). Other studies have shown variety to be related to pupil attention (Walberg, 1986). It is clearly difficult when teasing out the impact of ICT interventions to decide to what extent any gain in pupils' attainment is due to the instructional variety (or novelty) that computers and other forms of ICT offered, and to what extent the gain was due to the ICT itself.

A further aspect of this variety is the form of representation. Teachers use mainly verbal explanations, with occasional visual support (e.g. pictures and diagrams). ICT clearly offers the opportunity to combine forms of representation through multimedia (e.g. text and speech, sound and pictures). Increasing the range of representation, through the use of multimedia, for example (Collins et al., 1997), may be beneficial in itself, as this might support different learning styles.

Variety in teaching and learning style is also associated with learning gains: active, interactive whole class teaching and co-operative small group work have their merits, and the amount of time to be spent on both should depend on factors as pupil age, ability and, most crucially, the task to be performed or the subject to be learned (Galton *et al.*, 1980; Mortimore *et al.*, 1988; Bennett & Dunne, 1992).

Collaborative small-group work

Because of the difficulties of managing the turn-taking of a large numbers of pupils, some observers (Barnes and Todd, 1977/1995; Edwards and Furlong, 1978, Edwards and Mercer, 1987; Edwards and Westgate, 1994) have advocated the use of collaborative group work as a way of 'decentralizing' classroom communication so as to encourage more pupils to participate in and practice forms of academic discourse normally dominated by the teacher. Many teachers and researchers (e.g. Phillips, 1985; Reid *et al.*, 1989; Berrill, 1990; Maybin, 1991) have explored the possibilities of teacher-less discussion as an alternative to whole class recitation.

Collaborative group work has also drawn a lot of theoretical justification from the 'social constructivist' view of learning (see for example Barnes and Todd, 1995) because it allows more space for pupil initiatives or elaboration of ideas by regularly involving them in problem solving activities and sustained discussions of their own ideas. Therefore learning and teaching are seen as collaborative and involving the social and cultural perceptions of all participants; and talk is central to this process as it is the primary medium of interaction which enables learners to make explicit what they know, understand and can do. Computers certainly have the potential to alter the structure of talk in the classroom and act as a focus for effective collaboration in group work (Wegerif and Scrimshaw, 1997).

In discussing the features of group work where pupils are encouraged to explore meanings collaboratively, Edwards and Westgate (1994) and Barnes and Todd (1995) point out the clear differences in discourse structure between this and whole class instruction. Because the absence of the teacher means there is no authoritative figure to dominate the discourse, there are no clearly-marked asymmetrical relationships and the consequent lack of pre-allocated rights makes it necessary for the pupils to negotiate the terms of their interaction as they go along. This is also what happens when pupils work collaboratively at the computer as the teacher is rarely present (Wegerif, in Wegerif and Scrimshaw, 1997). As Edwards (1980) argues, turn-taking is managed locally and interactionally in such group discussion and it sets up different expectations and patterns of working because speakers potentially have equal rights and joint ownership of the interaction. The patterns of interaction are therefore strikingly different from the kinds of discourse associated with the whole-class or transmission model of teaching. Therefore there are frequent overlaps and a lack of pauses as it is usually not clear until the moment of decision who will enter and who will control the up-coming turn. Each pupil's contribution is also closely contingent on the contributions of others and necessitates close listening to what has gone before. The absence of an authoritative figure in the conversation also means that there is no one to evaluate responses so pupils have to pool their responses to draw their own conclusions or refine their responses. It also allows for an interplay of alternative frames and relevance, and because power is distributed amongst the pupils they have a greater opportunity to initiate questions, to evaluate each other's responses, and to control the discourse for their own purposes.

In this way, as Edwards and Mercer (1987) suggest, pupils can share in and practice forms of academic discourse of the classroom normally dominated by the teacher: that is, sharing, comparing, contrasting and arguing from different perspectives, providing opportunities for 'instructional conversation' or the 'shared construction or negotiation of meaning'. Therefore pupils are given more opportunities to develop linguistically and cognitively in the discourse structure of collaborative group work. Cazden (1988) also argues that collaborative group work has a justifiable role on the grounds that it is 'The only context in which children can reverse interactional roles with the same intellectual content, giving directions as well as following them, and asking questions as well as answering them, is with their peers'.

Bennett and Dunne (1992) and Galton and Williamson (1992) argue that successful group work only occurs when pupils are made aware of the aims of the task, and the skills and behaviours that are essential for its effective operation. They strongly advocate training in group work skills: for example, this might entail knowledge of how to listen, to question or challenge within a group discussion. They also emphasise the need for teachers to make their expectations explicit through clear 'ground rules' so that the pupils realise the importance teachers attach to such behaviours. By emphasising and encouraging such co-operative effort, and by providing feedback about the gains, Bennett and Dunne suggest pupils will perceive the value and benefits of talking and collaborative group work.

Research suggests effective teachers know how to blend individual, small group and whole class teaching successfully. Thus, for the teaching of basic skills or factual knowledge, active whole class teaching is clearly the most effective strategy, though practice or assessment of concepts taught might fruitfully incorporate some small group work. For example, mathematical problem solving and thinking skills are probably best enhanced through collaborative small group work, although an element of whole class teaching will be needed to explain the task and to teach the pupils the skills necessary to do collaborative group work (Peterson, 1988; Hembree, 1992; Stevens and Slavin, 1995). All in all, the research literature suggests that the question is not whether to do whole class teaching or small group work, but how to do them both, in a blended fashion (Galton and Williamson, 1992; Barnes and Todd, 1995; Galton, 1995). It seems likely that teaching practice which blends teacher-led approaches with group work and paired work remains the organisational and behavioural blend which will produce the highest learning gains (Croll and Moses, 1988; Johnson and Johnson, 1990; Pollard *et al.*, 1994).

To summarise, the research literature suggests the effective teacher:

- Uses attention-gaining devices (e.g. begins with a challenging question, visual or example);
- Shows enthusiasm and animation through variation in eye contact, voice and gestures (e.g. changes pitch and volume, moves about during transitions to new activity);
- Varies modes of presentation (e.g. lectures, asks questions, then regularly provides opportunities for independent practice);
- Uses a mix of rewards and reinforcement (e.g. verbal praise, independent study etc.);
- Incorporates pupil ideas or participation in some aspects of the instruction (e.g. uses indirect instruction or divergent questioning);
- Varies types of questions and statements (e.g. divergent, convergent, and probes, e.g. to clarify, to solicit, to redirect);
- Use an appropriate blend of whole class, group-based and individual teaching.

Teacher task orientation

This effective behaviour refers to how much classroom time the teacher devotes to the task of teaching an academic subject. The more time dedicated to the task of teaching a specific topic, the greater the opportunity pupils have to learn. Most researchers agree that pupil performance is higher in classrooms with teachers who spent the majority of their time teaching subject-specific content as opposed to devoting large amounts of time to the process and materials that may be needed to acquire the content. It follows that classrooms in which teacher-pupil interactions focus more on intellectual content than on process issues (such as how to use materials or classroom rules and procedures) are more likely to have higher rates of achievement (Brophy and Good, 1986; Hafner, 1993, Herman and Klein, 1996). Also, teachers who are task orientated are highly conversant with topics that are likely to appear on performance assessments and end-of-year achievement tests. They do not 'teach to the test', rather their classroom instruction parallels the instructional goals and curriculum that guide the construction of assessments of pupil progress.

To summarise, the research literature suggests the effective teacher:

- Develops unit and lesson plans that reflect the most relevant features of the curriculum guide or adopted text (e.g. each unit and lesson objective can be referenced back to the curriculum guide or text);
- Handles administrative and clerical interruptions efficiently (e.g. giving out of materials) by anticipating some tasks and deferring others to non-instructional time);
- Stops or prevents interruption with minimum of classroom disruption (e.g. has

pre-established academic and work rules to 'protect' intrusions into instructional time);

- Selects the most appropriate instructional model for the objectives being taught (e.g. primarily uses direct instruction for knowledge and literal comprehension objectives and indirect instruction for inquiry and problem-solving objectives);
- Builds to unit outcomes with clearly defined events (e.g. weekly and monthly review, feedback, and testing sessions).

Engagement in the learning process

This key behaviour refers to the amount of learning time devoted to an academic subject and is one of the most recently researched teacher behaviours related to pupil performance (e.g. Brophy and Good, 1986; Hafner, 1993, Herman and Klein, 1996). It is related to a teacher's task orientation and to content coverage, thereby providing pupils with the greatest opportunity to learn the material to be assessed.

Being given the 'opportunity-to-learn' is clearly related to such factors as length of the school day and year, and to the amount of hours devoted to each subject. It is, however, also related to the quality of classroom management, especially to what is known as time-on-task (i.e. the amount of time pupils are actively engaged in learning activities in the classroom, as opposed to socialising etc.). Opportunity-to-learn is also clearly related to the use of homework, which expands available learning time.

A highly important factor to distinguish effective teachers from less effective, a factor that is also connected to children's time-on-task, is the teacher's academic orientation discussed in the previous section. Effective teachers emphasise academic instruction, and see learning as the main classroom goal. This means that they spend most of their time on curriculum-based learning activities, and create a task-oriented, businesslike, but also relaxed and supportive environment. They spend time on academic activities rather than on personal matters, group dynamics, socialising or free time (Brophy and Good, 1986; Griffin and Barnes, 1986; Lampert, 1988; Cooney, 1994).

Several research studies (e.g. Bennett *et al.*, 1984; Bennet and Dunne, 1992, Galton and Williamson, 1992; Wragg, 1993) have contributed useful data for increasing learning time and, more important, pupil engagement both in whole class and in small group work. Their work has provided the following suggestions for teachers to promote pupil engagement:

- set ground rules that let pupils attend to their personal and procedural needs without obtaining the teacher's permission each time;
- move around the room to monitor pupils' work and to communicate awareness of pupil progress;
- ensure that independent or group-based assignments are interesting, worthwhile, and easy enough to be completed without the teacher's direction;
- minimise time-consuming activities such as giving directions and organising the class for instruction by writing the daily schedule on the board so as to ensure pupils know where to go and what to do;

- make abundant use of resources and activities that are at, or slightly above, a pupil's current level of functioning;
- avoid 'timing errors': act to prevent misbehaviour from occurring or escalating so they do not influence others in the class.

Pupil success rate

A crucial aspect of the research on task orientation and pupil engagement has been level of difficulty of the material presented. In these studies, level of difficulty was measured by the rate at which pupils understood and correctly completed exercises. The three levels of difficulty are as follows:

- high success, in which the pupil understands the task and makes only occasional errors;
- moderate success, in which the pupil has partial understanding but some substantive errors;
- low success, in which the pupil does not understand the task.

Findings suggest that a teacher's task orientation (instructional time) and pupil engagement are closely related to pupil success rate. Instruction that produces a moderate-to-high success rate results in increased performance because more content is covered at the learner's current level of understanding. This applies not only to expository or didactic forms of instruction in basic academic skills, but to thinking skills instruction. Research has also shown that instruction that promotes low error rate (high success) can contribute to increased levels of self-esteem and to positive attitudes toward the subject matter and the school (Slavin *et al*., 1996).

Subject specificity

Whilst there are teaching factors that are functional in generating high gain across all curriculum areas, a review of research by Borich (1996) also suggests that there is a degree of 'subject specificity' in what makes a difference. For example, in the teaching of mathematics effective teaching instruction includes the use of differentiated materials, whole class interactive instruction and the limiting of unguided or independent work, whereas in the teaching of reading it includes discussing, explaining, and questioning to stimulate cognitive processes and promote learner responses. Mortimore *et al.* (1988) also show subject specificity with the regular use of tests showing gains in mathematics but having a negative effect upon reading.

Teaching lower-SES and higher-SES Pupils

Borich (1996) in a review of classroom research into behaviours which promote the most achievement amongst pupils from low and high socio-economic status (SES) groups suggests the following approaches. Although some questions need to be raised about the extent to which his approach identifies SES as a proxy for attainment, and the danger of making assumptions about pupils' potential according to their background, Borich's findings have some relevance and so are reported here. For lower-SES (or lower attaining) pupils he claims teachers need to:

- provide a warm and encouraging classroom climate by letting pupils know help is available;
- encourage an initial response from a pupil, however crude, before moving to the next pupil;
- present material in small pieces, with opportunities to practice what has been learned after each piece;
- emphasise knowledge and applications before teaching patterns and abstractions (i.e. present most concrete learning first);
- monitor each pupil's progress at regular intervals (e.g. by using progress charts to help record improvement);
- help pupils who need help immediately (e.g. using peer and cross-age tutors, if necessary);
- minimise disruptions by maintaining structure and flow between activities (e.g. by organising and planning transitions in advance;
- supplement standard curriculum with specialised materials to meet the needs of individual pupils (e.g. by using different media, learning resources, and the personal experience of pupils to promote interest and attention).

And for higher-SES pupils:

- check right answers by requiring extended reasoning;
- pose questions that require associations, generalisations, and inferences;
- encourage pupils to use this same level of questioning;
- supplement curriculum with challenging material, some of which is slightly above pupils' current level of attainment;
- assign homework and/or extended projects that require independent judgement, discovery, and problem solving using original sources of information obtained outside the classroom;
- encourage pupil-to-pupil and pupil-to-teacher interactions in which learners take responsibility for evaluating their own learning;
- actively encourage pupils in verbal questions and answers that go beyond text and workbook content.

Teacher affect or emotions, in which teachers convey their enthusiasm to pupils in many ways, the most common being vocal inflections, gestures, eye contact and animation, is believed to be important in promoting pupil engagement in the learning process, particularly amongst lower-SES classes. Borich argues that four of the approaches shown for lower-SES classrooms (pupil responses, over-teaching/over-learning, classroom interaction individualisation) can be seen as special ways of creating pupil engagement at high rates of success. Also, frequently correcting wrong answers in the absence of warmth or encouragement could be construed as personal criticism by the less confident pupil, who already may have a poor self concept. Therefore, feedback that could be construed as criticism may need to occur in the context of a more consistently warmer and encouraging environment than may be needed for the more confident learner. Or, to put it another way, feedback needs to take into account the quality of the relationship between teacher and learner. In addition, activities such as discussion and problem-solving may require more structure (and preparation) for different learners.

Review of important teacher effectiveness indicators

In summarising the general indicators of effective teaching that are currently supported by the research literature, the effective teacher:

- takes personal responsibility for pupil learning and has positive expectations for every learner;
- matches the difficulty of the lesson with the ability level of the pupils and varies the difficulty when necessary to attain high success rates;
- gives pupils the opportunity to practice newly learned concepts and to receive timely feedback on their performance;
- maximises instructional time to increase content coverage and to give pupils the greatest opportunity to learn;
- provides direction and control of pupil learning through questioning, structuring and probing;
- uses a variety of instructional materials and verbal and visual aids to foster use of pupil ideas and engagement in the learning process;
- elicits responses from pupils each time a question is asked before moving to the next pupil or question;
- presents material in small steps when necessary with opportunities to practice;
- encourages pupils to reason out and elaborate on correct answers;
- engages pupils in verbal questions and answers;
- uses naturally occurring classroom dialogue to get pupils to elaborate, extend and comment on the context being learned;
- gradually shifts some of the responsibility for learning to the pupils - encouraging independent thinking, problem solving and decision making through collaborative group work;
- provides learners with mental strategies for organising and learning the content being taught.

Obviously, teaching involves a sense of timing, sequencing and pacing that cannot be conveyed by any list of behaviours. It is the thinking that connects these behaviours together that is important to the effective teacher, giving each its proper emphasis in the context of the classroom. It is the combination of curriculum, learning objectives, instructional materials and learners that provides the decision-making context for the reflective practitioner. It also points to the need for coaching and feedback to go hand-in-hand with teachers' professional development. Observation schedules to record teacher-pupil interactions can provide a useful tool for professional development as they allow for sympathetic discussion by groups of teachers of data derived from their own classrooms. This is a challenging agenda requiring evidence from classroom contexts analysed by qualitative approaches and markers of 'quality' which do justice to the contextual complexities of the classroom.

Methodological perspectives on analysing classroom interaction

There are, as Edwards and Westgate (1994) show in their extensive review of research methods, a bewildering variety of practical procedures and theoretical standpoints which compete for attention and from which a researcher of classroom interaction can choose. Generally speaking, there are five main traditions of classroom interactive analysis: systematic observation, ethnography, insightful observation, conversational analysis and discourse analysis; however, many studies of classroom interaction tend to be eclectic in nature and draw on more than one tradition. In deciding on a method of analysis, Edwards and Westgate warn that any system for analysing classroom interaction will have its limitations as all such systems have to simplify and reduce the complexity of what goes on in classrooms. They argue that all researchers have to make simplifying assumptions about that part of the social world which they seek to investigate if they are to gather data, and therefore all observation is selective and all forms of recording partial. The criteria for selecting an appropriate methodology will depend, they suggest, on the context of the question the researcher wants to answer.

Systematic observation

In the last three decades international research into effective teaching has focused on the impact that specific teacher behaviours have on the specific cognitive and affective behaviours of their pupils. The main focus of this research has been the study of pupil and teacher-pupil interaction in the classroom using systematic observation.

During the 1970s and 1980s, researchers developed new methods for studying the interactive patterns of teachers and pupils. The goal was to discover which teaching behaviours promote desirable pupil performance, such as good grades on classroom tests, higher standardised scores, better attitudes towards school and learning, and improved problem-solving and thinking skills.

To collect data on the classroom interaction of teachers and pupils, researchers often use observation schedules to record observations of various pupil-teacher behaviours. This method of analysis makes use of a predetermined system of categories. Such schedules are designed to survey lessons by requiring the observer to classify the interactional function of what is being said or done into categories which can be readily counted, grouped and analysed. Some schedules operate on a timed system, such as coding the interactional function every three seconds, others recorded continuous interaction over longer periods of time. The categories are therefore intended to describe the interactions observed as far as is necessary to do so for the researcher's purpose. The best known scheme for analysing classroom language is Flanders (1970, 1976) which originally had ten 'verbal interaction categories', most of which related to teacher talk and which produced the 'two thirds rule' for the frequency of teachers' questions; although he modified his categories to capture more of the reciprocal nature of classroom talk as in other systems (e.g. Amidon and Hunter, 1967).

Observation schedules are easy to use, reliable, replicable and are an efficient way of allowing broad comparisons to be made about teacher-pupil behaviour, particularly in transmission teaching. From such research (e.g. Hargie, 1978), general patterns of classroom interaction have been identified which show the frequency with which teachers ask questions, and that most of the questions were factual, mainly eliciting brief recalls of already provided information because the pace of the interrogation left little room for thinking aloud.

However, it is the level of generalisation that critics see as one of the main limitations of this method because of its attempt to simplify and reduce the complexity of the classroom to manageable proportions. Coding categories focus on behaviour rather than the structure of the discourse. The coder is expected to use an everyday or agreed understanding of language to do the coding, and it is usually assumed that the coder can do this in an unproblematic way. This leads researchers using systematic observation to make general assumptions about verbal interactions in order to categorise them and which necessarily limit their scope. It is assumed that what is said will be interpretable from the words alone.

This has been challenged from researchers from a linguistic background who make use of the wider context to interpret the level of meaning and categorise the exchanges, as meaning depends heavily on the shared context of the participants developed through past encounters. In other words, systematic analysis relies to a large degree on familiarity with the setting (Delamont, 1984) on the part of the observer to recognise the impact and effect of what has been said, since no formal or explicit definition is given of how the utterances are to be coded into different categories. Croll (1986), however, defends such methods by arguing that the observer's coding of teacher and pupil behaviours depends not on insights into their minds, but on their access to conventional ways of assigning meanings to words and acts as part of the communication process.

Research instruments in the project

In the project we devised observational instruments drawing on the approaches of earlier researchers and identified particular aspects of classroom interaction which we wished to focus on. Two types of schedule were used. One for whole class observations where the teacher was the focus of the observations. Categories included praise, verbal and non-verbal feedback, marking with regular timed off task scans. Other aspects of lessons such as transitions length of lesson segments were also recorded. The second observation schedule focused on pupils while they were using ICT and recorded types of talk (academic, operational and social) by pupils and helpers involved in ICT activities. Summaries of the findings at an individual level were presented to the development teachers with information about how their classroom compared with the overall range of observations.

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Appendix 4: Some relationships between teachers' thinking and observed behaviour

4.1 The range of data

The research looked at :

- teachers' outline career histories (especially any experience of extended professional development with ICT or involvement in ICT projects);
- pupils' responses to questions and their level of engagement in ICT activities;
- pupils of different abilities (particularly SEN);
- four lesson observations: two focused on literacy and numeracy (where the teacher was the focus) and two for ICT (where the pupils were the focus and with one involving literacy and the other numeracy where possible);
- the way teachers gave feedback in these lessons, and their assessment and monitoring (both orally and in written comments and assessment).

The observational focus was on:

- lesson phases (introduction/whole class, task /group session, plenary/ review);
- the number and types of activities;
- ICT activities;
- the teacher's praise and feedback (verbal, non-verbal, positive, negative);
- pupil initiation and extended interactions (teacher/pupil,

pupil/pupil);

- scans of on/off task behaviour at regular intervals (every 5 minutes in teacher-focused observations and every minute in pupil-focused observations).

Brief discussions with teachers before and after sessions noted planning and intentions for the sessions as well as a brief review of expectations. A part of the interview focused on teachers' choices through identifying their constructs about teaching and learning activities.

The data collection took place between February and April 1998. Thirty six schools were approached after the questionnaires had been analysed and the list narrowed down to a balanced sample of teachers who were known to be average or high in terms of the PIPS value-added measures.

The four lesson observations, the semi-structured interviews and the questioning exercise were completed with 32 of these teachers. We observed a literacy and a numeracy lesson which was part of their usual teaching week. We then asked to observe a literacy and a numeracy lesson where there was some ICT being used. This was in order to ensure that we observed lessons which were as typical a part of the teacher's practice as possible and to include some ICT in our observations. In total four observations of about an hour each were conducted for each teacher. In the interview teachers were asked questions about themselves, their teaching and their use of and views about ICT. The questioning exercise asked teachers to identify similarities and differences between statements about teaching and learning in order to explore how they thought about teaching and learning generally and about ICT activities in particular.

The data from these observations and the question responses were then coded and entered into a database. This enabled relationships between the original questionnaire data, the lesson observations and the questioning exercise to be investigated.

4.2 Construct elicitation exercise

The 32 teachers in the observation phase of the project took part in an activity designed to elicit their thinking about a range of teaching and learning activities and the relationship between ICT and teaching and learning. They were each presented individually with cards with three different teaching and learning activities on them (the process is know as triadic questioning). They were asked to identify in what way two of the activities were similar, yet different from the third. Their responses were recorded and represented different ideas or 'constructs' about teaching and learning.

(The approach is based upon personal construct psychology which is a system of psychology developed by George Kelly and expounded in his two-volume work: Principles of Personal Construct Psychology (New York: Norton, 1955). The theory has been applied in a number of fields including education. There is extensive information about the approach on the WWW: http://www.brint.com/PCT.htm is a good starting point.)

Overall the teachers varied considerably in the number of ideas or constructs they expressed when presented with the cards. (The exercise was discontinued if no new constructs were emerging). The range was from 9 to 26, with a mean of 17. The three teachers who were IT co-ordinators expressed significantly more constructs about teaching and learning than the sample as a whole. This may be a result of the inclusion of a number of activities referring to ICT.

The number of constructs expressed may of course be an indication of the interest of the teachers in the research process, of their energy levels on the day interviewed, of the sophistication of their understanding of pedagogy and ability to verbalise this, of their general level of thinking, or of any combination of these. Overall, there was no significant relationship between the number of constructs and value-added data. However, there were some other relationships of interest.

Teachers with a large number of constructs tended to have pupils who:

- read more in both number and literacy lessons;
- read more during numeracy ICT activities;
- wrote for longer periods during English lessons;
- made more learning-related initiations;
- were more often engaged with the teacher in extended talk to develop understanding;
- were more actively involved in plenary and review sessions.

Regarding ICT, these teachers:

- had greater non-shared access to computers;
- devised more activities to support computer programs (e.g. supporting activities to be done away from the computer).

This particular set of relationships suggests a teacher with a lot of ideas managing interrelated activities, providing time for extended reading and writing and wanting pupils to become actively involved in their learning through developing their own interests and thinking. While there is no suggestion that this type of approach is ineffective, it is essentially neutral so far as high value-added results are concerned.

At the same time, some teachers do manage to combine high levels of activity and pupil involvement with a sense of purpose which leads to positive outcomes in terms of learning gains and attitude towards school and core curriculum subjects (as measured by PIPS).

4.3 Construct ranking exercise

These constructs were then organised according to their opposites on a bipolar scale (some constructs had more than one opposing idea and so were presented more than once with the different contrasting constructs) and the teachers asked to express a preference for one end of the scale or the other. Following an exploratory factor analysis, twelve reliable composite scales were established which represent the self-ratings of 19 teachers on 60 of 70 elicited constructs (the remaining 10 constructs are not considered here as they did not cohere with these scales.) Our twelve composite measures were then related to other data on the same teachers, taken from the 1997 and 1998 questionnaires and from the 1998 classroom observations. Each of the composite measures represents a dimension of the teachers' thinking, some of which are distinctly different and some of which overlap. The twelve composite scales are listed below with the two most salient scales first, followed by subject-related scales and then other pedagogical dimensions in order of salience:

- teacher direction rather than pupil choice
- pupil empowerment as learners rather than pupils receiving instruction
- relatively high importance of mathematics in relation to English teaching
- group-work rather than class-teaching, emphasising literacy rather than numeracy
- a positive rather than a negative attitude towards ICT
- a preference for individual study rather than working with others
- a structured rather than a less structured approach to teaching and learning
- learning by discussion and pupil enquiry rather than by mechanical instruction
- using a formal and specific rather than an informal and general approach
- active learning of subjects rather than a less active topic-based approach
- preferring complex problems and tasks to simple and straightforward ones
- presenting work that is new and interesting rather than routine and repetitive.

Composite scales of teachers' thinking about teaching and learning

(n=19)

Here we list the sets of bipolar constructs which make up the 12 composite scales. Statistics showing internal consistency and correlational links with teaching experience and value added are also provided.

(1) TEACHER DIRECTION (Cronbach's alpha 0.93)

teacher)(pupils making decisions

teacher directing)(children choosing

teacher)(pupils planning

closed)(open activities

pupils being organised)(organising themselves

pupils being guided by the teacher)(being independent

r with years teaching 0.60** r with value-added 0.04 (Maths 0.27 Reading -0.19)

(2) PUPIL EMPOWERMENT AS LEARNERS (Cronbach's alpha 0.92)

pupils investigating)(teacher instructing

pupils checking their work)(teacher marking pupils' work

practical tasks)(paper and pencil tasks

teaching skills)(concepts

finding out)(being taught

using questioning)(direct instruction by teacher

pupils reflecting)(reacting

oral work)(written work

pupils being active)(not being active

child-led)(teacher-directed activities

r with years teaching -0.49* r with value-added -0.18 (Maths -0.39 Reading 0.06)

(3) INDIVIDUAL STUDY rather than WORKING WITH OTHER PUPILS (Cronbach's alpha 0.88)

individual)(group activities

individual)(collaborative activities

pupils working on their own)(pupils interacting

individual activities)(social activities

r with years teaching 0.05 r with value-added 0.21 (Maths 0.21 Reading 0.16)

(4) PREFERENCE FOR TEACHING MATHEMATICS rather than ENGLISH (Cronbach's alpha 0.87)

maths tasks)(English tasks

number tasks)(language tasks

meeting all pupils' needs)(meeting individual needs

activities without reading)(with reading

maths tasks)(language tasks

r with years teaching -0.20 r with value-added 0.13 (Maths -0.14 Reading 0.34)

(5) ENCOURAGING PUPILS TO STRUCTURE THEIR THINKING (Cronbach's alpha 0.83)

pupils listening)(rather than pupils communicating

children developing their own strategies)(being taught efficient strategies

learning from structured tasks)(learning from open-ended tasks

developing mental skills)(developing physical/motor skills

structured activities)(creative activities

activities with writing)(activities without any writing

r with years teaching 0.46 r with value-added 0.17 (Maths 0.15 Reading 0.13)

(6) DISCUSSION AND UNDERSTANDING rather than MECHANICAL INSTRUCTION (Cronbach's alpha 0.88)

activities with discussion)(without discussion

pupils needing)(not needing to know the purpose of a task

tasks with observable outcomes)(tasks where the learning is not observable

tasks teaching many skills)(tasks teaching one skill

finding things out)(learning things by heart r with years teaching 0.42 r with value-added -0.11 (Maths -0.05 Reading -0.14)

(7) CHILDREN USING LANGUAGE rather than BEING INSTRUCTED (Cronbach's alpha 0.85)

literacy)(numeracy

group activities)(class activities

applying knowledge)(learning new knowledge

teacher listening to)(talking to children

r with years teaching -0.03 r with value-added 0.10 (Maths 0.03 Reading 0.13)

(8) MEANINGFUL AND SPECIFIC rather than IMPRECISE TARGETS (Cronbach's alpha 0.83)

specific learning activities)(general learning activities

formal learning)(informal learning

having an audience for work)(having no audience

interpreting)(recording

r with years teaching 0.43 r with value-added 0.19 (Maths 0.21 Reading 0.13)

(9) ACTIVE TEACHING THROUGH SUBJECTS rather than LESS ACTIVE TEACHING THROUGH TOPICS (Cronbach's alpha 0.79)

teaching through subjects)(teaching through topics

active)(passive

r with years teaching 0.42 r with value-added 0.19 (Maths 0.25 Reading 0.02)

(10) COPING WITH DEGREES OF UNCERTAINTY AND DIFFICULTY (Cronbach's alpha 0.86)

tasks with several answers)(tasks with one answer

complex tasks)(straightforward tasks

pupils problem-solving)(pupils getting correct answers

tasks which have multiple solutions)(answers which are right or wrong

interpreting)(classifying

r with years teaching -0.08 r with value-added -0.14 (Maths -0.40 Reading 0.14)

(11) VALUE OF USING ICT (Cronbach's alpha 0.88)

tasks without a computer)(with a computer

activities without ICT)(with ICT

activities without machines)(pupils using machines r with years teaching -0.14 r with value-added -0.11 (Maths -0.20 Reading 0.01)

(12) LEVELS OF CHALLENGE AND NOVELTY (Cronbach's alpha 0.85)

introducing new ideas)(consolidating ideas

activities with calculating)(with no calculating

pupils working things out)(pupils recalling facts

pupils doing new things)(pupils repeating things

pupils initiating)(pupils responding

exciting activities)(routine activities

r with years teaching 0.45 r with value-added 0.19 (Maths 0.10 Reading 0.22)

The following single constructs did not cohere well with the above groupings:

(13) CALCULATOR USE

r with years teaching -0.32 r with value-added -0.09 (Maths -0.39 Reading 0.21)

(14) COMPLEX rather than SIMPLE TASKS

r with years teaching -0.06 r with value-added 0.01 (Maths -0.17 Reading 0.18)

(15) EMPHASIS ON DECODING rather than COMPREHENSION

r with years teaching -0.31 r with value-added -0.07 (Maths -0.05 Reading -0.07)

(16) PUPILS DOING THINGS rather than THINKING

r with years teaching 0.11 r with value-added -0.21 (Maths -0.08 Reading -0.28)

(17) FINDING INFORMATION rather than USING IT

r with years teaching 0.19 r with value-added 0.04 (Maths 0.05 Reading 0.02)

(18) INDIVIDUAL rather than WHOLE CLASS ACTIVITIES

r with years teaching -0.08 r with value-added 0.47 (Maths 0.33 Reading 0.49)

(19) LEARNING INSIDE rather than OUTSIDE THE CLASSROOM

r with years teaching 0.47* r with value-added -0.09 (Maths 0.26 Reading -0.38)

LEARNING NEW SKILLS rather than PRACTISING SKILLS

r with years teaching 0.05 r with value-added -0.22 (Maths -0.39 Reading 0.21)

A RELATIVELY NOISY rather than A RELATIVELY SILENT CLASSROOM

r with years teaching -0.22 r with value-added 0.17 (Maths 0.05 Reading 0.23)

PUPILS TALKING rather than PUPILS LISTENING

r with years teaching -0.22 r with value-added -0.17 (Maths -0.13 Reading -0.17)

Most of the correlations with value-added are close to zero, the highest being a negative (but non-significant) r of -0.40 between value-added in mathematics and a preference for complex problems with more than one answer.

More complex relationships

When we looked at the relationships between teachers' thinking and observed practice in literacy and numeracy lessons, some meaningful and statistically significant correlational links emerged. These form the basis of the interpretative paragraphs that follow. Taking each composite scale or dimension in turn, we examine (a) links with related sets of ideas and beliefs, (b) links with ICT-related data, (c) observational and self-reported links with pedagogy and (d) value-added in literacy and numeracy. The levels of statistical significance given are from two-tailed tests, with one asterisk representing the five percent and two asterisks the one percent levels. However, in some cases results of marginal significance are quoted to support the interpretations, especially where two results support each other.

Again it must be stressed that these relationships were investigated to support the development work and may not be generalisable. The number of teachers for whom full data was available was only 18 for the 1997 questionnaire and observational data and 19 for the 1998 construct and questionnaire data. Of the latter, 8 teachers taught Key Stage 1 and 11 Key Stage 2 pupils.

Teacher direction rather than pupil choice

> This dimension of the teachers' thinking was the clearest and most prominent of all. Nine teachers positioned themselves towards the teacher direction end of the continuum, with four towards the pupil choice end. A belief in the importance of teacher direction was significantly stronger in the more experienced teachers.[1] It was also linked with some of the other clusters of ideas and beliefs, notably the need for teachers to encourage pupils to structure their thinking [2] and a preference for straightforward closed activities.[3] A belief in the need to restrict pupil choice was associated with the idea of putting limits on pupil investigation [4] and reflection,[5] with a corresponding emphasis on direct instruction [6] and on written rather than oral work.[7] Teachers expressing these beliefs were generally not in favour of computers and ICT,[8] while those who favoured pupil choice and pupil empowerment as learners tended to have pro-ICT attitudes.[9]

[1] r=0.60** [2] r=0.64** [3] r=0.71** [4] r=-0.75**

[5] r=-0.70** [6] r=0.59** [7] r=0.63** [8] r=-0.53*

[9] r=0.55*

> b) Teachers who emphasised teacher direction rather than pupil choice tended to have a lower level of self-rated ICT competence [1] and gave much lower estimates of computer time per pupil per week.[2] Although they were quite likely to provide access to computers during playtimes,[3] they reported relatively little use of more demanding computer activities with spreadsheets and databases.[4] Highly directive teachers felt that access to more appropriate subject software would not increase their use of ICT.[5] When they did provide ICT activities, their pupils often engaged in social chat [6] with helpers and in maths lessons were more likely to talk with peers about functional than about academic aspects of the task.[7] While ICT did not feature strongly in either the thinking or the practice of the more directive teachers, they were more likely than others to make use of regular help from other adults in their classrooms.[8]

[1] r=-0.39(n.s.) [2] r=-0.56*('97), r=-0.53*('98) [3] r=0.49*('97)

[4] r=-0.63** ('98) [5] r=-0.60* [6] Maths/ICT:r=0.56*, Eng/ICT:r=0.54*

[7] r=0.66** [8] r=0.56*('97)

c) Pedagogically, teachers who valued teacher direction were observed in their maths teaching to review previous related work,[1] to model procedures for pupils to follow,[2] to refer back to stated lesson aims [3] and to make reference to future work.[4] When pupils made mathematical errors, highly directive teachers were more likely than others to signal this to pupils with non-verbal gestures and expressions.[5] In their English teaching the features just described were less in evidence, but teacher dominance was seen in that plenaries often took the form of a summary by the teacher,[6] accompanied by illustrative examples and counter-examples.[7]

[1] r=0.49* [2] r=0.53* [3] r=0.58* [4] r=0.57*

[5] r=0.67** [6] r=0.55* [7] r=0.55*

d) The degree of importance attached to teacher direction proved to be completely neutral in relation to the composite measure of value-added for maths and reading.[1] While there was no statistically significant link with maths value-added,[2] teacher direction was associated with significantly *lower* reading value-added scores in KS1.[1]

[1] r=0.04(n.s.) [2] r=0.27(n.s.) [3] r=-0.81*

Pupil empowerment as learners rather than pupils receiving instruction

a) In many ways this dimension of teachers' thinking is the *teacher direction rather than pupil choice* dimension in reverse. The links in the data with reported views and observed practice support the statements made above under the teacher direction heading.

b) Both the quantity and quality of pupil's ICT experience tended to be high with the teachers who took the pupil empowerment stance. With these teachers pupils often sought teacher help with functional problems when using ICT to support numeracy.[1] Teachers favouring pupil empowerment placed high value on subject-specific software [2] and felt that there was a shortage of this.[3] They were also inclined to feel that it is more time-consuming to prepare lessons that include ICT activities.[4]

[1] r=0.74** [2] r=0.64** [3] r=0.62* [4] r=0.47(n.s.)('97),

r=0.44(n.s.)('98)

c) A significant link was found between the extent to which teachers valued the empowerment of learners and the use of ability groups for literacy work [1] (a practice which was not a positive predictor of value-added in literacy in any age-group [2]). In KS1 literacy lessons, the pupil empowerment stance was associated with the teacher reviewing learning aims [3] and making reference to future work,[4] although this did not apply in maths lessons. Indeed, at KS2, a belief in pupil empowerment was *negatively* linked with reviewing previous related work in maths lessons[5], reviewing maths learning aims/objectives,[6] and referring to future work in maths.[7] While there is no evidence for direct causal links here, interesting questions are raised regarding the *appropriate* explicit use of lesson aims and objectives (in view of the fact that neither stating them [8] nor reviewing them [9] was a significant overall predictor of high value-added outcomes).

[1] r=0.57* [2] KS1: r=-0.24(n.s.), KS2: r=-0.48(n.s.) [3] r=0.73(n.s.)

[4] r=0.73(n.s.) [5] r=-0.71* [6] r=-0.68(n.s.) [7] r=-0.74*

[8] Maths: r=0.27(n.s.), English: r=-0.08(n.s.) [9] Maths: r=-0.17(n.s.), English: r=-0.03(n.s.)

A belief in the empowerment of pupils as learners seemed to be associated with positive value-added outcomes in KS1, especially in reading.[1] On the other hand, there appeared to be an inverse relationship between the pupil empowerment dimension and maths value-added in Y2 and Y4.[2]

[1] Maths: r=0.23(n.s.), Reading: r=0.68(n.s.) [2] r=-0.52(n.s.)

High importance given to teaching mathematics rather than English

a) Some teachers placed relatively high value on maths in relation to language and literacy development. They also had a strong preference for whole-class teaching rather than group [1] and individually-focused work.[2] The pro-maths attitude was also associated with a liking for complex tasks [3] and for tasks with more than one answer.[4] The teachers who shared these views were, however, no more likely than others to have responsibility as maths co-ordinators.[5]

[1] r=0.51* [2] r=0.79** [3]r=0.66** [4] r=0.51*

[5] r=0.12(n.s.)

b) Pro-maths teachers reported relatively little use of computers for number work,[1] word-processing [2] and the practice of basic skills.[3] They were unlikely to allow pupils to go to a computer after completing non-ICT work.[4] They had taken very few courses offered by ICT co-ordinators.[5] However, they did not believe that computers require too much technical knowledge [6] or that pupils lack essential keyboard skills.[7]

[1] r=-0.54* [2] r=-0.46(n.s.) [3] r=-0.49* [4] r=-0.53*

[5] r=-0.66** [6] r=-0.63** [7] r=-0.46(n.s.)

c) So far as pedagogy is concerned, the pro-maths teachers were likely to make aims and purposes clear in their maths lessons,[1] but did not otherwise share common characteristics that showed up in our observations. However, they achieved relatively high levels of pupil engagement in English lessons.[2]

[1] r=0.57* [2] r=0.57*

d) Paradoxically, they were less successful in adding value in the area of mathematics[1] than in reading.[2] A possible explanation for this (which fits in with the teachers' thinking and with the nature of the PIPS maths tests)is that high value-added in maths was found to be associated with a preference for straightforward, simple tasks,[3] whereas value-added in reading was, if anything, associated with a preference for tasks with more than one answer.[4]

[1] r=-0.14(n.s.) [2] r=0.34(n.s.) [3] multiple r=0.62* [4] r=0.28(n.s.)

Group-work rather than class-teaching, emphasising literacy rather than numeracy

a) Teachers of younger (KS1) children were more likely than the KS2 teachers to favour this approach.[1] It is influenced by a belief in the relatively high importance of literacy in relation to numeracy and is exemplified by the teacher listening to children working in groups as they apply previously learned knowledge. The approach was associated with a preference for topic-based activities rather than subject teaching.[2]

[1] Kruskal-Wallis test, p<0.05 [2] r=0.49*

b) So far as computer use is concerned, the stronger the teacher's belief in the importance of children working in groups on language and literacy tasks, the lower their estimate of the time that their pupils worked on computers each week.[1] When computers were used however, this was quite often for numeracy work [2] (which these teachers believed to be less important!) Computer work also tended to be used as a 'filler' [3] or reward activity.[4] The teachers rated themselves as having relatively poor computer skills, notably in the literacy-related skill of using a spell checker.[5] They also acknowledged a limited grasp of terminology used in ICT.[6] It appears that they had a preference for 'foolproof' software, as they tended not to use applications in which changes could be made by the user.[7] Also, few occurrences were recorded in English lessons of help being needed with functional ICT problems.[8]

[1] r=-0.60*('97), r=0.63*('98) [2] r=0.49*('97), r=0.36(n.s.)('98)

[3] r=0.47*('97), r=0.44(n.s.)('98) [4] r=0.39(n.s.)('97), r=0.53*('98)

[5] r=-0.60* [6] r=0.52* [7] r=-0.51* [8] r=-0.51*

c) Pedagogically there were a number of worrying features associated with this approach. Off-task behaviour tended to be high [1] and some transitions were not managed well.[2] Teachers who favoured this approach and believed that listening to children was important tended not to get involved in maths lessons in extended talk to develop understanding [3] and tended not to provide many examples for children to add to or talk about.[4] They also tended not provide additional support for children with special needs, especially in maths lessons.[1]

[1] Maths: r=0.43(n.s.), English: r=0.42(n.s.) [2] r=-0.37(n.s.) [3] r=-0.54*

[4] r=-0.49* [5] r=-0.75**

d) Value-added outcomes tended to be negative for both literacy and numeracy with KS1 pupils,[1] but were essentially neutral at KS2.[2]

[1] Maths: r=-0.29(n.s.), Reading: r=-0.56(n.s.) [2] Maths: r=0.32(n.s.), Reading: r=0.19(n.s.)

A positive rather than a negative attitude towards ICT

a) Teachers with a pro-ICT attitude were inclined to favour pupil empowerment[1] rather than teacher direction[2] and were positive about pupils tackling complex and open-ended problems,[3] and working collaboratively rather than alone.[4]

[1] r=0.55* [2] r=-0.53* [3] r=0.46* [4] r=0.40(n.s.)

b) Pro-ICT teachers were generally keen on the use of ICT in education [1] and reported that ICT made them feel good about their teaching.[2] Four of them were ICT co-ordinators and as a group there is strong evidence that they gave priority to teaching children ICT skills with targeted assessment objectives.[3] The teachers themselves had substantially higher levels of computer skills [4] and were rather more likely than those with a negative attitude to have a computer at home which they used for school work.[5] They provided more opportunities for class computer usage [6] and were more likely to use computers for database work [7] and in large projects,[8] believing that pupils had adequate keyboard skills for using computers.[9] They thought that parents were positive about computers [10] and said that it was not hard to include computer work in the curriculum.[11] They were also positive about the educational potential of the internet.[12]

[1] r=0.57*('97) [2] r=0.56*('97) [3] r=0.61* [4] r=0.74**

[5] r=0.45(n.s.)('97) [6] r=0.51(n.s.)('97), r=0.51*('98)

[7] r=0.46(n.s.) ('97), r=0.79**('98) [8] r=0.55*('98) [9] r=0.50*

[10] r=0.62* [11] r=0.68** [12] r=0.51*

c) In their teaching pro-ICT teachers gave more significantly more feedback to pupils after correct responses than other teachers did.[1] They also tended to have longer plenary sessions [2] in which the teacher tended to use a question and answer format [3] and/or present a summary at the end of a numeracy lesson [4] and model processes for the pupils in English lessons.[1]

[1] Maths: r=0.51*, English: r=0.37(n.s.) [2] Maths: r=0.62**, English: r=0.44(n.s.)

[3] r=0.54* [4] r=0.50(n.s.) [5] r=0.50(n.s.)

d) Overall, however, a pro-ICT *attitude* was found to be neutral so far as value-added learning gains were concerned.[1] On the other hand, teachers with higher levels of ICT *skills* tended be the ones whose pupils achieved greater learning gains,[2] especially in mathematics.[3]

[1] r=-0.11(n.s.) [2] Internet skills: r=0.32(n.s.) [3] Internet skills: r=0.47*

A preference for individual study rather than pupils working with other pupils

a) Teachers expressing this preference were likely to value structured,[1] routine[2] and practice activities,[3] including written work.[4] They were also likely to prefer teaching without machines,[5] including calculators.[6]

[1] r=0.52* [2] r=0.66** [3] r=0.60* [4] r=0.55*

[5] r=0.65** [6] r=0.51*

They reported low levels of computer usage,[1] especially for number work [2] and basic skills.[3] However they acknowledged that pupils could cope with the complexities of computer software [4] and several allowed pupils to use computers during playtimes.[5] Pupils were reported to work on their own when they did use computers in the classroom.[6] Relatively high levels of off-task behaviour were seen when ICT was incorporated into English lessons.[7]

[1] r=-0.57*('97) [2] r=-0.57*('97) [3] r=0.60**('97) [4] r=0.51*

[5] r=0.39(n.s.)('97) [6] r=0.42(n.s.) [7] r=0.72**

Pedagogically, few distinctive characteristics were seen, except that teachers who favoured individual study provided many explanatory examples in maths lessons [1] and were less likely to have maths plenary sessions.[2]

[1] r=0.55* [2] r=-0.53*

d) In terms of value-added, teachers favouring individual learning obtained marginally better results than those who favoured social and collaborative learning,[1] but no statistical significance can be claimed here.

[1] r=0.21(n.s.)

A structured rather than a less structured approach to teaching and learning

a) This dimension identified some of the more experienced teachers[1] and those who had attended recent twilight INSET sessions concerned with literacy or numeracy.[2] Ideas about encouraging pupils to develop their thinking and written work within structured frameworks were associated with preferences for teacher direction[3] and individual work.[4]

[1] r=0.46(n.s.) [2] r=0.47* [3] r=0.63** [4] r=0.51*

b) Teachers favouring this approach generally believed that computer software was appropriate for the national curriculum [1] and felt that teachers often discussed ICT issues.[2] In the 1998 questionnaire, preference for a structured approach was linked with computer use by the teacher for class demonstration [3] and by pupils for extension [4] and project work.[5] Linking computer work to other curricular activities was not felt to be a problem by those who favoured structured teaching and learning.[6] However, below average computer usage was reported in both years.[7] Pupils often sought operational help from peers when using ICT,[8] and they were also likely to engage in social chat when using ICT.[9]

[1] r=0.61* [2] r=0.51* [3] r=0.49(n.s.) [4] r=0.62*

[5] r=0.57* [6] r=0.53* [7] r=-0.63**('97), r=-0.29(n.s.)('98)

[8] Maths: r=0.68**, English: r=0.37(n.s.) [9] Maths: r=0.35(n.s.), English: r=0.53*

c) Links from the observations with this structured approach included the teacher providing a summary [1] and making reference to future work at the end of English lessons [2] and the use of modelling [3] and counter-examples by the teacher,[4] especially in maths lessons. It is interesting that as well as using counter-examples to indicate what was *not* required, these teachers were also more likely to respond to incorrect responses from pupils by using non-verbal signals.[5]

[1] r=0.53* [2] r=0.67** [3] Maths: r=0.69**, English: r=0.33(n.s.)

[4] Maths: r=0.49*, English: r=0.29(n.s.) [5] Maths: r=0.59*, English: r=0.39(n.s.)

d) While none of the overall correlations with value-added reached statistical significance, when broken down by age they were generally positive, except with Reception pupils.

Learning by discussion and pupil enquiry rather than by mechanical instruction

a) The core of this set of constructs seems to be an emphasis on goal-directed pupil enquiry. Valuing discussion and wanting pupils to acquire understanding is set against learning by heart and recalling facts.[1] Most teachers who valued discussion and pupil enquiry also favoured an active approach to subject-based learning.[2] They liked to present new and interesting work [3] and tended to prefer complex problems and tasks to simple and straightforward ones.[4]

[1] r=0.48* [2] r=0.65** [3] r=0.53* [4] r=0.58**

b) Teachers sharing these views reported above average levels of computer usage per pupil per week.[1] This dimension of teachers' thinking bore no relation to their own level of IT skills,[2] but it was associated with a positive feeling about teaching that included ICT.[3] The teachers who most valued pupil understanding were more likely than others to be aware of a school development plan to develop the use of ICT across the curriculum.[4] There was suggestive evidence of increasingly purposive uses of ICT (for example, using spreadsheets and databases to study patterns and interconnections) by teachers who favoured discussion and pupil enquiry between 1997 and 1998.[5]

[1] r=0.61* [2] r=-0.01(n.s.) [3] r=0.55* [4] r=0.58*

[5] t=2.42, p=0.05(n.s.)

c) Examination of the lesson observation data suggests that this dimension of teachers' thinking is not often evident in their practice, as few significant links were found with observed behaviour. Two possible exceptions to this were that, in English lessons, teachers who valued discussion and pupil enquiry tended to wait longer for pupils to respond,[1] and during maths lessons were more likely to engage in extended talk to develop understanding.[2] Lesson phase transitions where ICT activities were involved were usually orderly.[3]

[1] r=0.40(n.s.) [2] r=0.54* [3] All r's sig.p<0.05

d) Overall there was no significant association with value-added outcomes.[1]

[1] r=-0.11(n.s.)

Using a formal and specific rather than an informal and general approach

a) This dimension overlaps with the previous one in that both are associated with a liking for discussion[1] and for tasks with observable outcomes.[2] However, here there is a tendency towards a clearer focus, perhaps more teacher direction[3] and a much greater emphasis on recording in relation to thinking.[4] The teachers who shared these preferences tended to be more experienced[5] and to have attended recent twilight INSET sessions concerned with literacy and numeracy.[6]

[1] r=0.52* [2] r=0.51* [3] non-sig. diff. between r's p<0.06

[4] r=0.79** [5] r=0.43(n.s.) [6] r=0.55*

b) These teachers made average or slightly above average use of ICT [1] and could see the contribution that ICT can make in different areas of the curriculum.[2] They did not believe that too much technical knowledge is required for pupils to use computers [3] and rated their own computer skills as being average or slightly above.[4]

[1] r=0.12(n.s) [2] r=0.60* [3] r=-0.51* [4] r=0.08(n.s.)

c) Pedagogically these teachers tended to have good levels of pupil engagement.[1] Pupils were generally more likely to offer ideas to these teachers,[2] and in maths lessons to provide more examples and counter-examples [3] and to demonstrate procedures in maths plenaries.[4] In this way the classroom observations were consistent with the teachers' expressed preference for specific tasks with observable outcomes that are presented to an audience.

[1] Maths: r=0.29(n.s.), English: r=0.42(n.s.) [2] Maths: r=0.56*, English: r=0.42(n.s.)

[3] r=0.53* [4] r=0.54*

d) So far as value-added is concerned, this dimension of teachers' thinking was marginally, but not significantly, positive.[1]

[1] r=0.19(n.s.)

Active learning of subjects rather than a less active topic-based approach

a) This preference was rather more common among experienced teachers[1] and was positively linked with a liking for tasks that teach many skills[2] and have observable outcomes.[3] Class teaching was favoured in relation to group work,[4] but this did not imply a preference for talking at rather than listening to children in class discussions.[5]

[1] r=0.42(n.s.) [2] r=0.64** [3] r=0.68** [4] r=0.53*

[5] r=0.50*

b) Teachers who preferred subject teaching to topic-based work reported greater satisfaction with their own computer skills [1] and in their classrooms said that they made use of these skills, notably for class demonstration and in work with spreadsheets and databases.[2] Evidence for an above average level of computer usage was found both in terms of teacher estimates of time per pupil per week,[3] but also in terms of the numbers of pupils seen using ICT.[4] Both questionnaires showed that the expressed preference for active learning through subjects was strongly associated with positive feelings about the educational value of ICT [5] and computers.[6]

[1] r=0.64** [2] r=0.57*(composite measure)

[3] r=0.44(n.s.)('97), r=0.36(n.s.)('98) [4] Maths: r=0.30(n.s.), English: r=0.43(n.s.)

[5] r=0.49(n.s.)('97), r=0.81**('98) [6] r=0.60*('97), r=0.79**('98)

c) Among the features we saw more often in teachers who preferred an active learning approach through subjects were: a slightly longer English lesson [1] that included a plenary,[2] the class teacher providing support for pupils with special educational needs,[3] demonstrating processes for pupils,[4] giving time for children to answer questions,[5] engaging in conversations designed to improve understanding [6] and giving more illustrative examples in maths lessons.[7] There were also positive signs of pupil engagement in terms of on-task behaviour [8] and orderly transitions within lessons.[9]

[1] r=0.58* [2] r=0.51* [3] Maths: r=0.49*, English: r=0.30(n.s.)

[4] Maths:r=0.37(n.s.), English: r=0.50* [5] Maths: r=0.52*, English: r=0.45(n.s.)

[6] Maths:r=0.47(n.s.), English: 0.60* [7] r=0.48*

[8] Maths: r=0.40(n.s.), English: r=0.34(n.s.) [9] Maths: r=0.52*, English: r=0.47(n.s.)

d) As many of the observed features proved to be positive indicators of high value-added outcomes, it was expected that this dimension of teachers' thinking would itself predict such outcomes. Here the evidence was mixed, since a significant correlation was found with the 1997 value-added data,[1] but not with that for 1998.[2]

[1] r=0.66** [2] r=0.15(n.s.)

Preferring complex problems and tasks to simple and straightforward ones

a) This set of ideas represents a preference for divergent rather than convergent thinking and can be interpreted as an interest in creativity. Teachers for whom this dimension was important were more likely to favour pupil empowerment as learners[1] rather than teacher direction.[2] They were also more likely to value pupil enquiry and the use of discussion to promote understanding.[3]

[1] r=0.74** [2] r=-0.71** [3] r=0.58*

b) According to the 1998 questionnaire, such teachers tended to view ICT favourably [1] and put forward relatively high estimates of computer time per pupil per week.[2] They reported relatively frequent use of computers for number work [3] and for analysing patterns and connections.[4] It is possible that creative teachers are happy to let computers do what machines are good at - presenting pupils with tasks that require convergent thinking. Another possibility is that some of these teachers like to have a complex set of activities to manage and support. Our observations showed that the 'divergent/creative' teachers often helped to sort out functional problems with ICT or made use of other adult help to do so.[5]

[1] r= 0.46* [2] r=0.51* [3] r=0.35(n.s.) [4] r=0.62*

[5] Maths: r=0.69**, English: r=0.32(n.s.)

c) We found no clear patterns of behaviour associated with this dimension of teachers' thinking.

d) Value-added outcome measures tended to be positive for reading[1] and negative for maths.[1]

[1] r=0.14(n.s.) [2] r=-0.40(n.s.)

Presenting work that is new and interesting rather than routine and repetitive

a) This dimension of teachers' thinking is largely independent of the others that have been described. However, there was an association between enthusiasm for introducing new, interesting and exciting activities and having pupils work with other pupils rather than individually.[1] There was also a significant link with the desire to promote understanding through discussion and pupil enquiry.[2] Rather more KS1 teachers than Y4 teachers [3] and more of the experienced teachers [4] valued this approach.

[1] r=0.67** [2] r=0.53* [3] Kruskal-Wallis test, $p<0.05$ [4] r=0.45(n.s.)

b) So far as ICT is concerned there were no clear links with this dimension in terms of attitude or reported frequency of usage. However, in the 1998 questionnaire there was a significant link between valuing new and interesting activities and using computers to analyse patterns and connections (activities which are likely to make pupils think).[1] There was also a tendency for pupils to chat to each other when using ICT in English lessons.[2]

[1] r=0.57* [2] r=0.50*

c) Consistent with valuing novelty is the inclusion of 'other' (sometimes unexpected) activities in lessons.[1] Teachers who favoured novelty and interesting activities for pupils were found to have longer plenaries in maths lessons,[2] in which pupils were encouraged to model and demonstrate processes.[3] They also said that they provided different or adapted maths tasks for the benefit of pupils with special educational needs.[4] Overall this dimension of teachers' thinking seems to be expressed through a number of strategies designed to interest and motivate pupils.

[1] Maths: r=0.65**, English: r=0.42(n.s.) [2] r=0.48* [3] r=0.67**

[4] r=0.49*

d) Although correlations with value-added did not reach significance, the indications were generally positive, especially with reading value-added at KS1.[1]

[1] r=0.53(n.s.)

4.4 Inter-observer agreement index

Inter-observer agreement trials were conducted as part of the development of the observation schedules, so some degree of convergence is to be expected as part of this process. Once the schedules has been finalised a single lesson was video recorded and the six observers taking part in the observation phase used the agreed schedule separately to record appropriate categories for that lesson. The results are given below.

(Between-observer variance were excluded in the error variance, 2-way ANOVA.)

Categories	Variable name	Intra-class corr.	Fisher's z
No. of off-task pupils	off_tsk	.887	1.42
Verbal feedback: Correct	fboc	.950	1.83
Verbal feedback: Incorrect	fboi	.959	1.95
Frequency of marking	mark	.743	0.95
Frequency of praise	praise	.751	0.97
Average inter-observer reliability (calculated using Fisher's z scores)		.89	1.42

Although there are clearly limitations in using video as a means to establish inter-observer reliability for lesson observations, in the time available this seemed to be the best solution.

Appendix 5: The range of schools in the development phase

20 teachers from four different year groups began working with the development phase of the project in April 1998.

Year group	Number of classes
Reception	3
Year 2	5
Year 4	12
Total	20

The schools come from 5 different LEAs (Newcastle, Gateshead, North Tyneside, Lancashire, Sandwell) and in a range of locations (urban/inner-city suburban/ rural). They included infant, junior, first and primary schools.

The schools were chosen in order to keep a balanced sample of teachers according to the relative attainment of the pupils as measured by PIPS and so that they could be supported by the project team effectively in terms of their geographical location. The group of schools in the North East was supported more intensively than the others. For the others, face-to-face was more difficult and support was supplemented with telephone, fax and (limited) e-mail contact. Electronic support was hampered by technical delays in schools getting connected to the Internet.

Recording the development

The main methods of recording the development were:

- the pupil attainment data (e.g. standardised tests or the 10 minute writing task);
- comparative baseline data from the observation phase;
- a project log of contact and interaction between the teachers and the members of the project team;
- a final questionnaire;
- interviews which focused on the teachers' choices and their perspective on the development phase;
- a construct ranking exercise which built on the construct questioning from the observation phase (discussed in Section 4).

The development phase aimed to produce examples of teachers attempting to become more effective (and discriminating) in their use of ICT to promote the development of literacy and numeracy skills in their pupils. Although the teachers kept records, evaluated pupil progress and reflected on their own professional development, the project did not have experimental and control groups selected from a nationally representative sample of schools. The data below is intended to show, however, that we worked with a wide range of schools and that they had different characteristics. Details in this section refer to the development projects in the North East, Lancashire and West Midlands. The data was collated from OFSTED reports available on the Internet.

School size

School in the development projects range in size from a small primary with just over 100 pupils to a large primary with nearly 400 pupils. The distribution is as follows:

School size: No. of pupils	No. of development schools in this range
100-130	2
131-160	3
161-190	3
191-220	5
221-250	3
251-390+	4

Schools by location

The project also worked with schools in a range of locations:

Urban/Inner city	7
Urban/suburban/town	8
Rural/village	5

Schools also varied considerably in the proportion of pupils with SEN (0% to 55%) and proportion of pupils receiving free school meals (from less than 2% to 71%).

Schools In London Docklands

There were a further five teachers taking part in the piloting of aspects of the project, supported the National Literacy Association (NLA). There was one Reception class, two Year 4 and two Year 5 classes. All development work here had a literacy focus, with two schools also undertaking further development in numeracy or in science. All schools made use of Acorn pocketbook computers for writing, the two Year 5 classes focusing on the built-in thesaurus application.

Other targeted areas for development in the Docklands schools included:

- SEN focus;
- developing the role of classroom helpers in supporting ICT;
- familiarisation with new PC equipment and software;
- starting to use the Internet and a new digital camera;
- using ILS to support class-based work;
- data-handling;
- retrieval skills recording ideas and planning.

The work undertaken by these teachers and NLA staff was invaluable in informing the development work in the project, both for trialling the research instruments, some of the specific ideas used in development schools and in foreseeing potential problems.

Appendix 6: Gains in pupils' attainment during the development work

Pupil attainment as measured by standardised tests during the development work

Statistically significant gains were achieved with six whole classes and in two cases with a target group of pupils within a class in the Summer term 1998. The results of this first term's work were discussed both between the individual teachers and project staff and with groups of development teachers. This information was then used in the planning of the second term (Autumn 1998). Significant gains were made in 14 of the 16 classes which were using standardised tests to measure pupils' progress.

Development phase Term 2: literacy results overall table

Year Group	Test	Number of pupils (completing both pre- & post-tests)	Pre-test Mean	Post-test Mean	Sig.
2	PARA	28	79.3	83.9	Y
2	RPTBL & 1	27	75.6	82.9	Y
3	RPT3	26	96.6	132.2	Y
4	RPT3 & 4	24	80.4	95.2	Y
4	RPT3 & 4	17	78.4	96.7	Y
4	RPT4	12	127.2	144.9	Y
5	RPT4 & 5	29	103.7	119.0	Y
4&5	RPT4	14	81.6	93.7	Y
4&5	PARA	14	93.2	96.1	N
4&5	RPT2	13	88.4	94.5	Y
5&6	RPT3,4,5&6	26	138.9	149.5	Y

Development phase Term 2: numeracy results overall table

Year Group	Test	No. of pupils (both tests)	Pre-test Mean	Post-test Mean	Sig.
R	EMC	24	82.6	97.3	Y
2	GMT	28	93.3	100.6	Y
4	BNS	29	118.7	123.9	Y
4	BNS	22	99.7	112.6	Y
5	BNS	8	117.4	122.3	N

Abbreviations key

RPT B & 1-6 - Reading Progress Tests Baseline and 1 - 6 (Vincent, Crumpler and de la Mare, 1997: Hodder and Stoughton)

PARA - Parallel Spelling Test A & B (Young, 1983: Hodder and Stoughton)

BNS - Basic Number Screening (Gillham and Hesse: Hodder and Stoughton)

EMC - Early Maths Concepts (NFER- Nelson)

GMT - Group Mathematics Test A & B (3rd Edition) (Young: Hodder and Stoughton)

Some caution is clearly necessary about inferring more general progress from the use of standardised tests, particularly when they are used over a relatively short period of time. However the teachers involved in the project valued the diagnostic information which it gave them and it was a valuable focus for discussion and review in the development projects.

The writing task

The task that we used to assess aspects of free writing was adapted from the Free Writing Scales developed by Hunter-Grundin and Hunter-Grundin (1980). Children were given 10 minutes to write a story on the topic 'On My Way to School'. They were asked to write about *things you see, things that happen* and *things that might happen* and were asked to try to finish their stories within the time available. They were advised not to spend time checking spellings and teachers were not allowed to supply spellings. At the end they read their stories to a neighbour and wrote down at least one thing that this neighbour liked about the story.

The writing samples were assessed for 'quality' (using a seven-point making scale), fluency (number of words written) and for spelling accuracy (percentage of words spelled correctly). The 'quality' criteria were based on the coherence and completeness of the story, as well as on the treatment of character, setting and ending.

In the first phase of development work (summer term, 1998) nine classes used the writing task to monitor progress in this paper and pencil task. We were not encouraging teachers to use computers more intensively for word-processing, and in most cases they continued with existing practices.

What we found in the first term was that the quality of writing improved significantly in three of the nine classes. The amount written in ten minutes also increased significantly in three classes, while spelling improved significantly in two.

Overall, the improvement in quality of writing was highly significant, and there was also a significant improvement in spelling. However, the average increase in the number of words written in 10 minutes was only one word (non-significant).

In the autumn term, 11 sets of results were collected and these are tabulated below. This time the quality of writing improved significantly in three of the eleven cases, while the amount written went up significantly in nine cases, but spelling only in one. Overall, the gains in both quality and quantity of writing were highly significant, while the improvement in spelling approached significance. The biggest increase was in the number of words written. This mean increase of 15 words is equivalent to the improvement normally expected in a year, according to a table compiled by Moseley (1997). It seems that some teachers had seen the activity as a means of improving pupil 'productivity', analogous to the first stage in drafting with ideas flowing freely.

It cannot be proved that the general increase in the number of words written was due to more or better use of ICT for word processing, since the reported frequency of use from 1997-1998 changed little. However, it is of interest that the three classes where the quality of writing improved significantly were all Year 2 classes and in each of there was substantial use of computers in the production of written work. Also, in most of the other settings teachers had been given hands-on experience in the use of talking word processors and several introduced this to pupils during the course of the project.

The results during the second phase of development were pleasing in that the quantity of written work increased, and this was achieved without sacrificing quality. The increase in output suggests that pupils were not losing motivation as writers, an issue that often becomes problematic as children get older, especially with boys (Gorman, White, Orchard and Tate, 1982). Boys and girls showed almost identical increases in the number of words written. However, boys made statistically significant improvements in the quality of their writing and in spelling, whereas the girls did not. Only further research will show whether this effect is ICT-related.

Development phase term 2: writing task results

Year Group	No. of pupils	Measure	Pre-test mean	Post-test mean	Sig.
2	23	Quality	2.3	3.7	Y
		Length	34.0	45.9	Y
		Spelling %	73.3	83.7	Y
2	29	Quality	1.1	2.7	Y
		Length	27.1	46.5	Y
		Spelling %	85.7	80.7	Y(neg.)
2	27	Quality	1.7	2.3	Y
		Length	17.9	43.4	Y
		Spelling %	79.9	82.1	N
3	25	Quality	3.8	4.4	N
		Length	59.9	74.3	Y
		Spelling %	84.3	86.1	N
4	26	Quality	4.0	4.4	N
		Length	64.4	75.7	Y
		Spelling %	91.0	91.4	N
4	39	Quality	3.7	3.5	N
		Length	66.2	76.7	Y
		Spelling %	86.5	88.3	N

4	12	Quality	5.3	5.3	N
		Length	78.7	102.3	Y
		Spelling %	95.2	96.4	N
4/5	13	Quality	3.8	4.1	N
		Length	43.7	64.4	Y
		Spelling %	81.3	79.1	N
4/5	9	Quality	3.8	3.8	N
		Length	72.3	77.7	N
		Spelling %	85.8	88.2	N
5	29	Quality	4.2	4.7	N
		Length	77.3	96.3	Y
		Spelling %	90.0	92.3	N
5	12	Quality	4.8	5.3	N
		Length	107.2	118.9	N
		Spelling %	92.0	91.6	N

References for Appendix 6

Gorman, T.P., White, J., Orchard, L. and Tate, A. (1982) Language Performance in Schools Primary Survey Report No.2. London: HMSO.

Hunter-Grundin, E. and Hunter-Grundin, H.U. (1980) The Hunter-Grundin Literacy Profiles, High Wycombe: The Test Agency.

Moseley, D.V. (1997) 'Assessment of spelling and related aspects of written expression', in J. Beech and C. Singleton (eds.), The Assessment of Reading, London: Routledge.

Appendix 7: Information on the WWW

There is always the danger that any reference to information or materials available through the Internet will become quickly dated. The sites listed below give further information about the agencies and organisations mentioned in the report.

The Teacher Training Agency (TTA): **http://www.teach-tta.gov.uk**

Department for Education and Employment (DfEE): **http://www.dfee.gov.uk**

The Standards Site: **http://www.standards.dfee.gov.uk/**

Scottish Office Education and Industry (SOEID): **http://www.scotland.gov.uk**

Department of Education Northern Ireland (DENI): **http://www.deni.gov.uk/**

Welsh Office: **http://www.wales.gov.uk**

OFSTED: **http://www.ofsted.gov.uk**

Qualifications and Curriculum Authority (QCA):**http://www.qca.org.uk**

BECTA: **http://www.becta.org.uk/**

National Grid for Learning (NGfL) : **http://www.ngfl.gov.uk**

New Opportunities fund (NOF): **http://www.nof.org.uk/**

The PIPS Project at the CEM Centre, Durham University: **http://cem.dur.ac.uk/pips/**

Newswise: **http://www.ndirect.co.uk/~sapere**

KidPub: **http://www.kidpub.org/**

Teachers' ICT skills and knowledge needs: Final Report to SOEID: **http://www.scotland.gov.uk/library/ict/**

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